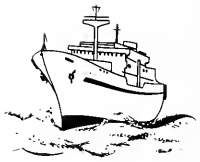
Massachusetts Industry

progress through enterprise



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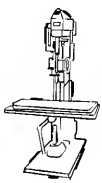

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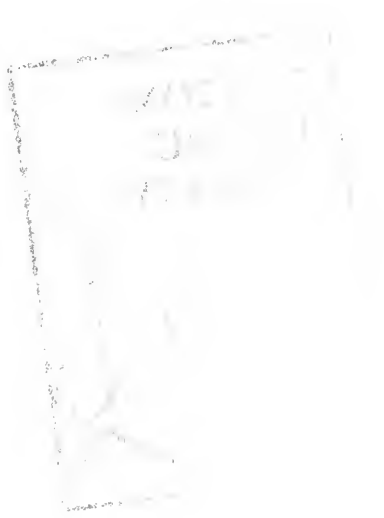
High-altitude view of Greater Boston, capital city of this great industrial state, photographed during aerial photography research program conducted by Itek Corporation, Lexington, and supplied courtesy of Itek.



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To my secretary, Miss Muriel Lockwood, for her untiring efforts far beyond the call of her duties, I owe a very deep and heartfelt debt of gratitude.

ROBERT A. CHADBOURNE
Executive Vice President
Associated Industries of Massachusetts

Boston, September, 1965

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Introduction

Man's natural inventiveness, given full support through our free competitive economy, has given this nation the highest standard of living in the world. Massachusetts, from the days of its early settlement, has contributed immeasurably to this progress. As the colonists became accustomed to a freedom they had never previously known, their active minds were free to apply themselves to bettering their standard of living.

Within the pages of this book the deeds of many men are told. These men, defiant of tradition, explored uncharted avenues of science and mechanics. Their only teacher was experience, their only guide, reason. They built, and rebuilt, looking for a better way. When they found a better way it ignited a chain reaction. A new, improved component for a loom required new machinery for its manufacture. Designing the new machinery stimulated other ideas and innovations. With each innovation a new industry was established. Related industries tended to stay in the same cities giving rise to "Jewelry Cities," "Shoe Cities," "Textile Cities." Suppliers of specialty equipment for these industries found it expedient to build nearby their market. Thus, an industrial complex was created that was as near self-sufficient as possible.

Improved transportation facilities, faster communication and the American competitive spirit forced many changes in these complexes as the twentieth century evolved. In the early nineteen hundreds the distance between buyer and seller was an uncomfortable few hundred miles and required an overnight of travel. Slightly more than a half century later an overnight trip could allow the traveller to go half way round the world.

Within that half century, a depression and two World Wars created monumental upheavals in our economy, testing the worth of our competitive system. Because of the diversity of its industries and industrial skills, Massachusetts adjusted, not without problems, to new industrial needs and consumer demands. The destiny of the state's prosperity and growth hinged on the capability of industry to develop and expand.

Starting with the Yankee craftsmen who learned by experience, Massachusetts has continued to develop its resources. Through specialized training, skilled workmen keep pace with changing skills required to meet new production demands. Our technical training schools and research centers are pioneering new industries and providing specialists with unusual skills.

Massachusetts indeed has an illustrious industrial heritage and has made many important contributions to our society of which all Bay Staters can be proud. To mention a few: Paul Revere, who founded the silverware and copper industry in Boston; the Saugus Iron Works, which was the beginning of America's metal industry; Goodyear's accidental discovery in Woburn of the process of vulcanization, which made possible the rubber industry of today; the first successful gasoline automobile, the Duryea, in Springfield; Dr. Robert Goddard of Worcester, father of modern rocketry and the space industry; Clarence Birdseye of Gloucester, who invented the quick-freezing process, the forerunner of the frozen foods industry. All these and many more interesting highlights are woven into the fabric of each chapter to provide a better understanding of the economic forces that really make Massachusetts a very important industrial state and one of the leaders in the nation.

The most common yardstick used to measure the industrial importance of an area is the amount of dollar value added in manufacture over a given period. Today, Massachusetts ranks as ninth in the nation in the value of the goods it produces.

Among the New England states, Massachusetts leads the way, not only by value added, but in number of companies and total industrial employment. In fact, in almost every industrial comparative statistic concerning the New England region, Massachusetts represents almost 50 per cent of the six state totals. Thus the economic prosperity of Massachusetts industry exerts a strong influence on the economy of the entire New England area.

Nearly every one of Massachusetts' 351 cities and towns claims one or more industries. In some towns a single industry supports the entire population, directly or indirectly. In others, near turnpike networks,

sprawling industrial complexes house plants producing a wide assortment of products. In total, Massachusetts has approximately 11,000 manufacturing establishments. Less than 100 of these employ over 1,000 people, 150 employ between 500 and 1,000; and about 300 employ between 250 and 500.

The greater percentage of the industrial work force of 660,000 is employed in smaller plants with less than 250 employees. These plants are one of Massachusetts' greatest assets for in them exists the potential for growth and employment as well as the creativity that promotes progress just as it did in the early centuries of our state's development.

Some will grow to be our major industries of tomorrow; others will fail. Under our profit and loss system which operates on the basis of free competition in the market, no company is assured of its success. Those that grow will help to absorb our ever-increasing work force. Since more people are employed in the state's manufacturing industries than in any other single category of employment, their continuing growth is vital to our economy.

The $3,610,482,000 per year that is paid in wages and salaries to the industrial work force is 47.2 per cent of all the wages and salaries paid to all the employees in the Commonwealth. Most of this returns directly or indirectly to the state's economy through the purchase of goods or services, or through investment or savings.

The authors of this book have traced the growth of industry in Massachusetts since Colonial days. You will read how industries within the state producing similar products have competed for business, and continued to grow. But because this book deals only with Massachusetts industry, it will not be apparent how many other industries outside the state are competing also for the same business. As modern transit reduces the size of the world, more competition is being added from other nations.

This is a challenge in which we all have a common stake. The customer who buys our products in the market is king. Whatever we manufacture has no economic value until it is bought and used.

The goal of this book is to present briefly an industrial history of what has gone before, to help us plan better for what is to come. Change is not new, only its environment and product is different. The pages of this book reflect years of radical change, proving that we need not fear its consequences. Between the lines we can read stories of the hard work and sacrifice that have been invested in the development of a product. Could we have met the challenge that we faced as a small state in the far northeast corner of an expanding nation without the inspiration of free enterprise?

Machinery alone cannot overcome a challenge. It takes the strength and abilities of many people, each investing his particular skill in a mutual effort to satisfy the demands of the buyer. This is the freedom of choice that has made us the most productive nation in the world. Massachusetts was founded by people who escaped to freedom to avoid indentured servitude. Industry grew here then, and grows now, because men with ideas and men with productive skills combine their talents to make it grow.

Because of the great number of manufacturing industries within the state we have been able to name only a few who have successfully adapted to change and displayed the enterprise to develop and grow. There have been many more whose progressive outlook has enabled them to expand with new products that have created new jobs and built up our economy. To them we are mutually indebted.

Changing times have all but obscured the old stone markers that once guided travelers along the old Boston Post Road, a proud accomplishment of the Bay Colonists. The changes that challenge us today are as great, if not greater, than the colonists faced. Freedom of enterprise, so new to the colonists, sparked their response to the challenge. We benefit from the progress they achieved, and future generations, endowed with the same freedoms, will draw increased advantages.

It is to this concept that MASSACHUSETTS INDUSTRY—PROGRESS THROUGH ENTERPRISE is dedicated.

The Primary Metals Industry

Saugus pioneers one of America's basic industries

More than 300 years ago, a century before the Revolutionary War, the first successful iron works in America was in operation in Saugus. This birthplace of the iron and steel industry in America has been restored through the financial efforts of the American Iron and Steel Institute, and today the restoration stands as a tribute to the industrial pioneers of three centuries ago. Opened to the public on September 17, 1954, this reconstructed historic site, now one of Massachusetts' proudest industrial landmarks, is visited by thousands every year.

Using bog iron ore from nearby swampy fields and the dammed waters of the Saugus river for power, the Hammersmith works, as this first ironworks was called, produced up to 100 tons of iron a year. Fires were fed with charcoal made by burning trees from the surrounding forests. Iron, produced from ore with a mixture of iron bearing rock from Nahant, was cast into pigs. These were then reheated, refined into wrought iron and then pounded with a giant trip-hammer into rods, rolled into strips and slit to width for many purposes. Crude iron cooking pots were directly cast from the molten metal, and one of the famed Saugus pots provided restoration metallurgists with data of the chemical composition of the iron.

The little Saugus works gave the spark to the industry in the Bay State where metal parts for ship gear, kettles, and tools were in great demand. Iron in those days sold for about $100 a ton. It was a very valuable metal. Limestone, an essential ingredient in the production of pig iron, was scarce in the eastern part of the state and the industry gradually moved nearer to the western part where there are large limestone deposits. Although the Saugus plant had a relatively short life, it did far better than the other American iron works financed by English investors. That one, in Virginia, was sacked by the Indians who massacred the entire work force.

While plentiful supplies of water, bog ore, wood, and shellheaps inspired early development of iron works around the Bay State, it was the developing industrial revolution that was to demand specialty metals and alloys. Metal production progressed from bog ore castings to steel, brass, bronze, and copper.

Neighbors in the machinery industry discussed metals problems in the development of a new part, arriving at a solution that created a whole new industry. New methods of casting cut production time; forging produced formed parts of greater strength; drawing made blanks for a thousand different uses. The ingenuity of the machine industry found a strong supporting partner in primary metal developers.

The primary metal industry today is roughly divided into two categories. The first is the smelting and refining of ferrous (derived from iron) and nonferrous (relating to metals other than iron) metals from ore, pig metal (named for the crude shape in which it is hardened), or scrap. The second is the processing of these metals into various shapes by rolling, drawing or pulling, casting, and forging either in their pure state or through alloying or combining with other metals. Massachusetts has a substantial number of manufacturing companies engaged in one or more of these primary metal processing operations, geographically scattered over a large number of cities and towns throughout the state. Employment in this industry totals nearly 22,000 and produces an annual payroll of just under $130,000,000.

Largest employer in the primary metals industry in Massachusetts is the segment of the industry engaged in the rolling, drawing, and extruding of nonferrous metals. This segment, which includes many large companies producing insulated wire, provides jobs for nearly 8,162 persons.

The second largest employer in the industry is the segment engaged in rolling, drawing, and finishing steel. Employment in this segment totals about 4,370.

Classified as "miscellaneous primary metals industries" is a group including large forging companies like the Wyman-Gordon Company in Worcester. This group employs about 4,316.

Iron and steel foundries provide jobs for about 3,045 and nonferrous foundries for about 1,625.

The Revolution was still in progress when the first steel furnace was put in operation in this state; and, a few years later, development of machinery for the manufacture of nails began.

Nails and tacks are still made in Massachusetts. Independent Nail Corporation in Bridgewater, and

Atlas Tack Corporation in Fairhaven, are the largest Massachusetts producers of these essential products. In Whitman, the D. B. Gurney Co. since 1825 has manufactured all types of small cut tacks and nails made from sheet steel, brass, or copper, as differentiated from wire nails. In addition, the large majority of their products are used in automatic shoe machinery and for attaching metal buttons, and are in reality a precision product.

But in the primary metals products, this state really shines as the leader in the production of wire. As early as 1812, experiments in drawing fine wire had been made in Spencer by Windsor Hatch and Charles Watson. Their efforts resulted in the establishment of a small wire industry in that town and eventually led to the creation of the Wickwire-Spencer Steel Corporation, which for many years operated large wire-making plants in Spencer and Worcester. The business was taken over by Colorado Fuel and Iron Corporation, which today produces wire, wire rope, and other wire products in a large plant in Palmer.

The making of wire accounts for a major portion of employment in the primary metals industry in the state. Development of Massachusetts' dominant role in wire production largely revolves about the establishment and growth of a company in Worcester which for five decades operated under the firm name of the Washburn & Moen Manufacturing Company. Because of the many new products and processes established by this firm during its early history, Worcester became known as the "Cradle of the Wire Industry." Some of the company's early accomplishments included the first American-made telegraph wire, the first American-made piano wire, the first open-hearth furnace in New England, and the first American-made insulated electrical wires and cables. Many other wire-producing firms in the state were formed by men who at one time or another worked for this enterprising firm.

In 1899, the company grouped with other wire companies as an important unit of American Steel & Wire Company, which became a subsidiary of the United States Steel Corporation. Now known as the Worcester Works of the United States Steel Corporation, this Worcester plant is the largest wire-producing facility in the state. Employing some 1,300 persons, it probably produces the greatest variety of wire products of any plant in the country. Wire from this plant is used in the binding of books, in the production of rubber tires, and in the manufacture of brooms, cotter pins, hairpins, musical instruments, paper clips, pianos, staples, and nails, to name a few products. In addition to rolling steel rods from billets for its own production of wire, the company also supplies other New England wire-producing firms with rods. It also produces cold-rolled steel sold to manufacturers of saws, surgical instruments, business machines, and textile machinery. The drawing of copper wire and subsequent manufacture

Electrical interlocked armor cable with thermoplastic jacket being wound on reel for shipment.

Tantalum ingot being lathe-shaved to eliminate rough edges prior to fabrication into tube for Dead Sea project.

of a wide variety of electrical cables for high voltage power transmission, mining machine equipment, oceanographic exploration, and oil well survey purposes are among the many items produced at the plant's electrical cable division which turns out over 1,200 tons per month for shipment to all parts of the world.

Another large wire producer in Worcester is National-Standard Company. This firm makes a wide range of wires varying from two one-thousandths of an inch in diameter (about the size of a human hair), used in industrial brushes for polishing, to one-quarter inch sizes, used for heavy-duty springs such as those in overhead garage doors. Its product list includes such items as aircraft wire, belt hook wire, brush wire. Copperply and Nickelply wire, fish hook wire, fuse wire, hose wire, mandolin string wire, music wire, safety pin wire, stitching wire, aircraft target tow wire, tire bead wire, and welding wire. The company also has another Massachusetts plant in Springfield, where the wire and belts used in paper-making machinery are produced.

Thompson Wire Company, a Massachusetts corporation, has plants in Boston and Worcester as well as four other locations in the United States. The company is the largest manufacturer in the world of shoe shank steel, brush wire, cardwire for the textile industry, shaft wire, and casing wire for automobile speedometer casings. The Boston plant manufactures cold-rolled strip and spring steel used largely in the stamping industry. The Worcester plant manufactures specialty fine steel wires.

Johnson Steel & Wire Company in Worcester, a subsidiary of Pittsburgh Steel Company, produces wires which are sold to manufacturers to be made into such varied products as bobby pins, musical instruments, steel rope, brushes, and beading for automobile tires. It is a leader in the production of so-called "music" wire, which is the wire commonly used in the manufacture of many types of springs.

New England High Carbon Wire Corporation in Millbury is a leading supplier of high carbon and alloy wire used to make springs for automobiles, home appliances, and typewriters. Among the auto parts made from the Millbury firm's wire are valve springs, clutch springs, and carburetor springs. The company also makes a type of wire used in textile machinery.

The Prentiss Wire Mill of H. K. Porter Company, Inc., located in a new million dollar plant in West Holyoke, is a fine specialty mill. Its principal product is stitching wire, the type of wire from which staples for desk staplers are made. The printing trade is a large user of stitching wire which has general usage in packaging for the stapling of cartons. The plant also produces nickel wire, used in weaving operations and in communications equipment. G. F. Wright Steel & Wire Company in Worcester is a leading manufacturer of poultry netting (chicken wire) and a heavier netting used by operators of small animal farms. The company also makes hardware cloth (cellar window wire), wire strand used to guy up TV antennas, and industrial wire cloth used for plant protection.

Rathbone Corporation, which operates a cold drawing mill in Palmer, produces precision profile sections and pinion rod for use as parts in appliances, radios, cameras, business machines, model railroads, toys, firearms, and aircraft. In cold drawing, metal is shaped by drawing it through dies. Besides brass, steel, monel metal, nickel, and silver, other metals can be precisely shaped by this process. The first product of the Palmer firm, established sixty years ago by Andrew Rathbone, was a type of cold drawn pinion rods which were sold to clock manufacturers for gears.

One of the brightest chapters in the story of Massachusetts' contributions to the primary metals industry has been written by the Wyman-Gordon Company of Worcester. This company, the leading producer of aircraft forgings in the U.S.A., pioneered in the heat-treating of forgings and for many years has been in the forefront of technical advances in the art of forging.

Besides its headquarters plant in Worcester, the company operates a USAF facility in nearby Grafton and has plants in Harvey, Illinois; Los Angeles, California; and Bombay, India. The Grafton plant's 50,000-ton hydraulic press is the largest machine of its kind in the country. With this 10-story giant, other big presses, and a battery of hammers rated up to 35,000 pounds, the company produces a wide variety of forgings from all metals, including steel, aluminum, magnesium, high temperature nickel alloys, titanium, beryllium, and refractory metals. Wyman-Gordon is a major supplier of forgings to the aerospace, automotive, and farm implement industries.

The firm was started in 1883 by two 22-year-old graduates of Worcester Polytechnic Institute, Horace Winfield Wyman and Lyman Gordon. The boys were set up in business by their fathers, both of whom were executives of the Crompton Loom Works in Worcester.

The business remained small for several years. Most of the orders were for small forgings to be used in textile machinery.

Not until the bicycle craze swept the country in 1890 was there any

surge of business for the young firm. Then came a deluge of orders for hubs, pedals, sprockets, forks, and spindles for bicycles. And from that era to the present day the history of the company has been closely tied to the history of transportation.

When the bicycle craze faded, the company found business in supplying car couplers to the railroad industry. A sad experience with its first production of car couplers led to the development of a process of heat-treating to toughen the forgings. This episode was to have a profound effect on the company's future.

The car coupler business vanished when foundries developed a method of casting knuckles for car couplers which enabled them to undersell the forging shops. Fortunately the changing transportation industry provided Wyman & Gordon with a new customer to take the place of the railroads. Electric cars were just beginning to replace horse cars on street railways and the Worcester firm of Washburn & Moen, which had been making copper wire since 1884, had received contracts for trolley wire and for copper rail bonds needed for electrification of railways. Washburn & Moen decided to sub-contract the rail bonds, which were required in more than 100 different lengths, sizes, and patterns. Remembering Wyman & Gordon's success with the coupler knuckles, they contracted with the versatile Worcester firm to produce the rail bonds.

Arriving next on the transportation scene was the automobile. Here again Wyman & Gordon found a lucrative market. With its knowledge of heat treating, the company produced crankshafts which were far superior to those used in many of the early cars. The crankshaft business expanded with the growing auto industry, and by 1922 Wyman-Gordon was producing 90 per cent of all crankshafts forged in the United States. In the intervening years to the present the big auto manufacturers have installed crankshft-making facilities of their own, but Wyman-Gordon is still a large producer of crankshafts for passenger cars, trucks, and tractors. Its Harvey, Illinois, plant produces more crankshafts than any other plant in the world.

Development of the aircraft industry gave Wyman-Gordon another opportunity. From the earliest days of flying, the firm has supplied forgings to the aircraft industry, at first for aircraft motors and later for aircraft frames. Its Worcester Division, comprising the Worcester and Grafton plants, produces a larger volume and a wider variety of aircraft forgings than any other plant in the world.

A second large forging operation in the state is that of the Moore Drop Forging Company which has operated in Springfield since 1900. "Drop Forging" gets its name from the fact that the process shapes the metal by dropping a heavy hammer containing a die on heated metal. The heated metal is resting on an anvil in which is the counterpart of the die. The impact of the hammer, like the blacksmith's blow, gradually forces the metal into the shape of the dies. Forgings are used for parts which must withstand unusual stresses of one kind or another. The forging process itself imparts strength and this can be further increased by heat treatment.

Forged aluminum structural parts and Hold-down post (*center*) for Saturn launch vehicle withstand tremendous stresses.

Strips of different kinds of metal are bonded together by cold rolling.

Forgings are also produced in presses and upsetters. This latter method applies pressure to the end of a metal bar and in this manner increases its diameter to fill a die cavity of the desired shape.

Moore Drop Forging supplies forged parts to leading manufacturers in the automotive, aircraft, and machinery industries. In addition, it machines, heat treats, polishes, and plates a wide variety of wrenches and other hand tools, completely packaged ready for the consumer. It is equipped with a well-staffed, modern laboratory to maintain control of both chemical and physical standards.

Moore Drop Forging Company, in addition to four plants in the Springfield area, operates two in Ohio. The capacity of one plant is devoted entirely to the manufacture of automotive door hinges while the other is engaged in the production of cold formed parts such as shafts and gun barrels.

Another Springfield firm which supplies many New England companies with forged parts is the Storms Drop Forging Company. The high strength to weight ratio of a forging has long been recognized. As a result, Storms furnishes most of the forgings in today's famous M-14 rifle, many of the wrenches and pliers, the bicycle crank, a variety of jet aircraft engine parts, and forgings for the space age.

Preparing mold for gray iron casting.

In Rockport, Cape Ann Tool Company makes closed die drop forgings for manufacturers of hand tools and valves. This 75-year-old firm also produces forgings for the automotive, chemical, and textile machinery industries.

The only malleable iron foundry in Massachusetts is the Belcher Malleable Iron Co. in Easton. Malleable iron, which is produced by prolonged heat treatment of the metal, the treatment lasting from a minimum of 48 hours to as long as seven days, is about twice as strong as ordinary gray iron. It is less brittle than gray iron and can be bent without breaking.

The Easton firm supplies malleable iron castings to many industries and includes among its customers companies making textile machinery, hand tools, pipe fittings, valves, and machine tools of all types.

Scattered around the state are numerous other companies making forgings in both ferrous and nonferrous metals. Outnumbering the forgings companies by far are the many foundries in the state which supply a wide variety of castings to the makers of all types of machinery. Shaped by pouring molten metal into molds, castings are generally used in machinery for parts not requiring forgings.

Most of the state's foundries are small, handling orders for various kinds of cast parts from local industries. Some of the big machinery firms, in addition to making castings for their own production, make castings for other manufacturers. Draper Corporation, a leading manufacturer of textile machinery, has a spacious foundry at its Hopedale plant and produces large quantities of gray iron castings for other textile machinery manufacturers, for valve manufacturers, and for the electrical industry.

Massachusetts foundries produce castings in all kinds of metals. There are no less than fifty foundries in the state specializing in casting made of gray iron, the ferrous material commonly used for castings. This must be distinguished from white iron, which is harder and less malleable. There are almost as many firms making castings of aluminum, widely used in the electrical and electronics industries as bases, housings, and fittings. There are about thirty foundries working with brass, bronze, and copper.

Castings of nickel, chrome, magnesium, monel and special alloys are also produced.

Shahmoon Industries, Inc., which acquired the venerable Warren Foundry & Pipe Corporation of Boston, has recently erected a new plant in Boston for the production of cast iron pressure pipe. The pipe is sold all over New England for use as water mains. Shahmoon's Boston plant is the only one in New England making this product. It produces pipe by a process in which centrifugal force sprays molten iron against the walls of a spinning mold, forming pipe of the exact thickness desired.

Total employment in foundries in the state is approximately 4,670.

A newer method of making metal parts, involving the use of powdered metals, is also represented in Massachusetts. The powdered metal is first pressed in dies to give it the shape of the desired object. Then it is placed in a high-temperature oven, where the heat solidifies and hardens it by binding the grains of metal together. Merriman Brothers, Inc. in Boston has been a

pioneer in the development of powdered metal techniques and there are several other Massachusetts firms in the field.

Until the beginning of the 19th century America had no facilities for rolling copper and had to import sheet copper from abroad. It was a Massachusetts metal craftsman who established the first rolling mill in this country. He was none other than Paul Revere of midnight ride fame.

Revere spent most of his life working as a silversmith. Early in his career, the exquisite silver bowls and pitchers which he designed and fabricated won him fame as an artisan. But his skill was not confined to silverware. During the Revolution he learned how to make brass cannon. After the war he established a foundry where he made household hardware and cast bells for New England churches.

When "Old Ironsides" was built, Revere furnished bolts, spikes, and pulleys for the construction of the famous warship. He had a keen interest in the birth of the American Navy at that time and he deeply regretted that he lacked the equipment to provide the copper sheathing needed to protect the ship's bottom. This item had to be imported from England.

Revere was so disturbed that America lacked facilities to produce its own sheathing that he determined to set up a rolling mill himself. Although he was then 65 years old, he risked $25,000 of his own money and borrowed from the government to get funds to build the mill.

The mill was built in Canton, a site chosen because of the availability of the Neponset River for water power. For sources of raw materials, Revere used scrap copper sheathings from ship bottoms, copper utensils, virgin copper from a mine in Simsbury, Connecticut, as well as small imports from England. Within a year of the start of construction, the mill was producing American-made sheet copper. Revere's first big order was for copper sheathing to cover the dome of the newly-erected State House in Boston.

A year or two later Revere received an order of greater significance to him. It was for copper sheathing for "Old Ironsides". The warship was being overhauled in drydock, a project which called for re-coppering. This time the copper sheathing was American-made. Thus Revere, who had a hand in America's obtaining political independence, also helped bring industrial independence to this nation.

After Revere's death the copper mill was operated by successive generations of Revere descendants. In 1900 the firm of Paul Revere & Son merged with Taunton Copper Manufacturing Company and New Bedford Copper Company, forming the Taunton New Bedford Copper Company. For a time, the Revere name disappeared from the firm name. But in 1928, when Taunton New Bedford Copper merged with several brass and copper companies in other parts of the country, the name chosen for the new corporation was Revere Copper and Brass, Inc.

Today Revere Copper and Brass, Inc. operates a rolling mill in New Bedford, where it produces copper sheet, strips, and plates which are sold to the aircraft, automotive, home appliance, electrical, and electronics industries. At the New Bedford plant the company also makes copper print rolls. These are widely used in the textile industry to print designs on fabrics.

Revere Copper has two other operations in the Bay State. A subsidiary in New Bedford, John I. Paulding, Inc., makes light switches, sockets, switch plates, and other electrical products. In Plymouth, the Edes Manufacturing Company Division makes zinc, copper, and magnesium engravers' plates for the printing industry.

In Taunton, the New England Brass Company produces brass strip used in the electronics, jewelry, and metal stamping industries. The Taunton rolling mill also makes bronze and nickel silver strip for industrial customers.

In the nonferrous field, as in ferrous, Massachusetts holds a leading position in the production of wire. There are some thirty companies engaged in the drawing and insulating of nonferrous wire.

Largest of the Massachusetts companies in this industry is Simplex Wire & Cable Company of Cambridge. Established in 1845 by Charles A. Morss and Oliver Whyte as a wire-working shop making such articles as bird cages and fire screens, the firm produced its first insulated wire in 1885. Its first contract was for wire for the first electric street lights in Boston. Today Simplex insulated wire and cable is shipped to all parts of the world.

The most dramatic of the company's accomplishments have been in connection with the laying of submarine cable. The company was a pioneer in the production of this type of cable, and its research staff through the years has developed important new materials for protecting cable from the elements.

Back in 1899, this Massachusetts firm manufactured five miles of submarine telephone cable to cross Michigan's treacherous Mackinac Straits. It was the longest submarine cable in the United States at the time. More recently it produced submarine cable for the first transatlantic telephone lines and for the telephone service linking California and Hawaii.

Almost 35 years of research were required before American Telephone & Telegraph Company was able to announce in 1953 that it planned to span the Atlantic with a submarine cable. The basic problem which had made transocean submarine-telephony so difficult was the fact that the electrical impulses carrying the human voice over long distances of wire tended to weaken. On land, the solution was simple. Amplifying equipment would boost voltage energy every few miles, making transmission over thousands of miles possible. But where could one build an amplifying station in mid-ocean? If islands were spaced at convenient intervals, submarine-telephony was practical. However, there was no such chain of islands and the idea of using floating stations was ruled out because the constant action of storms, tides, and waves, plus the possibility of damage from ships, would make such a solution hazardous.

The solution finally evolved was to incorporate the amplifying stations within the cable itself. The amplifiers, or "repeaters," would be in the form of electronic components linked together lengthwise in a flexible housing.

As finally designed, the repeaters were 8 feet long and contained 50 components tightly encased in 17 lucite containers. Recognizing that repairing a faulty repeater lodged at the bottom of the ocean would be a tremendously costly operation, telephone engineers insisted on extraordinary precautions in the manufacture of the repeaters. They were designed and made to last, under full service load, for at least twenty years.

Simplex designers and Bell Laboratories engineers worked together in designing the protective armoring for the cables and for the repeaters. All the armoring of the repeaters was performed by Simplex, both for the section of cable which Simplex itself supplied and for a section which was supplied by a British firm.

Laying of the transatlantic submarine telephone cable was successfully completed in 1956. The remarkable efficiency with which the cable has operated is a tribute to the know-how of the Massachusetts firm in cable-making.

Besides its plant in Cambridge, from which it supplies industrial customers around the world, Simplex has a plant at Newington, New Hampshire, specializing in submarine cable. This plant, built in 1953, is the largest of its kind in the country. It has its own docking facilities, making it possible for cable-laying ships to load cable directly at the plant.

While the steel business is largely concentrated in the Worcester area, the nonferrous wire business in Massachusetts is scattered in widely separated locations.

In the extreme western part of the state, at Williamstown, Cornish Wire Company, a division of General Cable Corporation, is an important producer of power cords for household electrical appliances and power tools. Besides its plant in Williamstown, which is housed in a former textile mill where corduroy cloth was once made, the company operates a second wire plant, in nearby North Adams, with plastic as the insulating and jacketing material.

Boston Insulated Wire & Cable Company is the second oldest wire and cable manufacturer in New England, being founded in 1905. Since this company was founded by Harry B. Burley, it has been dedicated to the design and production of high quality cables for particular types of electrical equipment and apparatus.

One of its first products was flexible electric control cables suspended under elevators for the Otis Elevator Company along with the motor leads to provide the power. In the years since then this company has been the foremost manufacturer of elevator cables, and practically all of the high rise, high speed elevators in New York skyscrapers are controlled by BIW cables.

Another leading product of the company is flexible cable for TV cameras. The first of these cables made for Radio Corporation of America at the New York World's Fair in 1939 became the beginning of a wide acceptance by the major studios as the most dependable for TV transmission. Today BIW cables are internationally adopted by foreign TV camera companies.

Boston Insulated Wire & Cable Company's wide range of specially designed cables, developed by a high proportion of trained cable engineers, has found many diverse applications; such as sonar cables for underwater research, radiation-resistant cables for nuclear-reactors, large multi-conductor cables for radar antennas, high temperature aircraft engine cables, and miniature wiring for satellites.

In its laboratory the company is continually searching for new materials and designs to meet special requirements of its industrial customers.

International Telephone & Telegraph Corporation's Wire and Cable Division plant in Clinton is a leading producer of electronic wire. It is also a large supplier of wire and cable to the aircraft, nuclear, and space industries.

The Clinton plant also manufactures wire, cable, and tubing for a wide variety of industrial uses. Its complete facilities for drawing wire, insulating, and sheathing spread over 14 acres, and it employs about 800 persons. The Phalo Corporation, a subsidiary of Transitron

Electronic Corporation, occupies a modern plant in Shrewsbury and employs approximately 500 people. It has complete facilities for wire drawing and stranding, and manufactures a broad line of cables, wires, cord sets, and tubing.

Other large producers include Gavitt Wire & Cable Company in Brookfield, Holyoke Wire & Cable Company, and Nonotuck Manufacturing Company in South Hadley.

A metal which is finding increasing use in applications where resistance to high temperature and corrosion is an important factor is tantalum. The National Research Corporation of Cambridge, subsidiary of the Norton Company of Worcester, is the only New England manufacturer of the refractory metal tantalum. It is also the world's leading producer of tantalum powder used in the manufacture of capacitors for computers, military electronic systems, and commercial communication equipment.

One of the metal skills which has been developed in Massachusetts is that of bonding one metal to another, producing what are known as "clad" or "laminated" metals.

Originally this process was applied to bonding pure gold to an inexpensive metal base to make "gold-filled" metal for the jewelry industry. Now clad metals are widely used for many industrial purposes.

The broadening of uses for clad metal began in the 1920's when silver was bonded to a base metal for electrical contacts. Shortly thereafter two or more metals with different thermal expansion characteristics were bonded together to make what is called "thermostat metal," which is widely used in various types of controls. It is the element in a toaster, for instance, which determines when the toast will pop up and is the means by which an automatic choke in an automobile functions.

A large supplier of clad metal electrical contacts, thermostat metal, and a wide variety of other composite materials is Metals & Controls Inc., a wholly-owned subsidiary of Texas Instruments Incorporated. This company's large plant in Attleboro provides employment for 3,000 persons.

In 1952 its experience in metal bonding led Metals & Controls to extend its operations into another field. It became the nation's first privately-owned fabricator of nuclear fuel.

A nuclear element comprises a fissionable material, such as uranium, clad with an outer layer of a protective material, such as stainless steel or zirconium alloy. The Attleboro firm fabricates these elements for electric utility power plants, for nuclear ships, and for research reactors.

When the United States Government decided to change the metallic content of its dimes, quarters, and half dollars, it turned to the Attleboro firm to supply it with rolled strips of the sandwich-type metals from which the new coins are minted. The dimes and quarters are a "sandwich" of copper between an alloy of nickel and copper. The half dollars have a silver-copper alloy on the outside with a filling of a different alloy of the same two metals.

Also located in Attleboro is another company with broad experience in the bonding of metals, the D. E. Makepeace Division of Engelhard Industries, Inc. This firm which has produced gold-filled metal for the jewelry industry for more than sixty-five years is now also a major producer of laminated precious metals for industrial uses. In addition, it is a major producer of precision waveguide tubing for the electronic industry and of form roll shapes for such applications as gas turbine engines and aircraft use.

The diversity of the primary metals industry has been shaped from its very beginning in Saugus three centuries ago to meet the constantly changing demands of a growing country. Although crude cast iron cooking pots are no longer in fashion, new markets, new products, new manufacturing techniques, and even newer metals have all helped to build a diversified primary metals industry as a vital stabilizing sector in our Massachusetts industrial economy.

Aircraft landing gear component of forged alloy steel being removed from forging press.

The Fabricated Metals Industry

For generations, an amazing array of products

"This Hardware Store Sells Only Products Made in Massachusetts." No store has ever made such an announcement of policy, but a hardware dealer could confine his stock to Massachusetts-made products and still offer his customers an almost complete line of merchandise. There would be a few missing items, but not many.

Hammers? Wrenches? Chisels? Drills? Screw drivers? Saws? Nuts, bolts, screws and washers? Pails and trash barrels? Grass clippers? Razor blades? Flashlights? Rules and gauges? Insecticide sprayers? Knives? Garden tools? Skate sharpeners? Door knobs? Locks and hinges? Wire cloth? Lawn sprinklers? Hose nozzles? Fireplace equipment? Barbecue equipment? Valves and pipe fittings? Heating equipment? Housewares? All of these are made by Bay State companies in the fabricated metal products industry.

In addition, there are segments of the industry that supply other industries with metal parts for their products, with metal equipment for their processing, or with metal containers for packaging. There are companies making fabricated structural steel and ornamental ironwork for the construction industry. There are concerns specializing in aluminum windows and doors. There is a long list of companies providing important metalworking services such as galvanizing, electroplating, engraving, and polishing. In all, there are about one thousand metal-fabricating firms in Massachusetts. Total employment in the industry in the state runs close to 40,000, which produces an annual payroll of nearly a quarter of a billion dollars and whose value added by manufacture totals $454 million.

By far the largest segment of the industry is that which makes tools, cutlery, and general hardware. This group, which includes companies whose products have been nationally famous for generations, accounts for more than one-fourth of the total employment.

Simonds Saw & Steel Company in Fitchburg, founded in 1832, is the world's largest manufacturer of saw blades. Besides saws, the company, which also has plants in other states, makes other so-called "expendable tools" (tools which wear out in operation and have to be replaced), including files, machine knives, and grinding wheels.

Manufacture of Simonds saw blades is concentrated in the main plant in Fitchburg, which employs about 1,000 persons. The company's line includes circular saws for both woodcutting and metalcutting, band saws for the lumber industry, hack saws, and blades especially designed for use in particular industries. Simonds makes circular saws as small as 2 inches in diameter and as large as 6 feet. The Fitchburg plant attained considerable prominence because it was the world's first windowless and "controlled conditions" factory, featuring complete control of lighting, temperature, humidity, noise, dust, and smoke.

The L. S. Starrett Company of Athol enjoys the reputation of being the largest company in the world devoted to the manufacture of precision-measuring instruments. The company employs about 1,200 persons in the manufacture of mechanics' hand-measuring tools, steel tapes, electronic gauges, dial indicators, vises, hack saws, band saws, and band knives. There are about 3,500 different sizes and types of items in the firm's catalogue.

Founded in 1880 by Laroy S. Starrett, whose central idea was to "invent something useful that people would want," the company is headed today by the great-grandson of the founder, Douglas R. Starrett.

An interesting sidelight on the company's operations is the dam at the Athol plant. Having suffered severe damage to its factory and some damage to the old dam in the late '30's as a result of floods and hurricanes, Starrett replaced its old dam with the first bascule dam ever built in the United States. This type of dam, developed in Germany, has a flap which automatically opens to spill water when the height of the flow exceeds a predetermined level.

A well-known manufacturer of tools for the hardware trade as well as for industrial users is Millers Falls Company. Founded in 1868 the Company has plants in Greenfield and Millers Falls employing about 1,300 people. The firm makes hand tools, portable electric tools, hack saw and band saw blades, and precision measuring tools.

In Springfield, the Moore Drop Forging Company makes mechanics' wrenches and a popular line of hand

tools which is sold nationally to home owners and do-it-yourselfers.

In Somerville is H. K. Porter Inc., which describes itself as "a manufacturer of metal-cutting tools for all industry." Besides hand and power-operated tools, this long-established concern makes automobile body and fender repair equipment.

Parker Manufacturing Company in Worcester is reputed to be the world's largest manufacturer of hack saw frames and coping saw frames. It is also the largest manufacturer in New England of saber saw blades and jig saw blades. The company was a pioneer in adopting a guaranteed annual wage plan, which has been in effect since 1939.

Hyde Manufacturing Company of Southbridge is the world's largest manufacturer of "fix-up paint-up tools" for the craftsman, decorator and home owner. Hyde painting and decorating tools are found in stores around the world wherever paint and wallpaper are sold. Hyde also is one of the world's largest suppliers of special hand and machine cutting tools for paper, plastic, rubber, textiles, synthetics and food.

Other leading tool manufacturers in the state include American Saw & Manufacturing Company which has recently moved into a new plant in East Longmeadow, Apco Mossberg Company in Attleboro, and Stevens Walden Inc. in Worcester.

Massachusetts' fame is carried around the world by the Gillette Company, whose principal plant, known as "World Shaving Headquarters," is located in South Boston. In 1903, King C. Gillette,

In a fountain of sparks two ends of a band saw are welded together.

founder of the business which today has annual sales of $300 million, first placed his safety razor on the market. Sales in that year totaled 51 razors and 168 blades. Since that time the company has rolled off its production lines some half-billion razors and more than 40 billion blades.

The laboratories which Gillette maintains at its Boston facilities to study hair-removal methods and products have made some interesting discoveries about Gillette blades. By using electron microscopes, capable of magnifications up to 150,000 times, they have found the edge of a Gillette blade to be substantially less than a wave length of visible light. This means it would require the edges of 750 blades to equal the thickness of a single sheet of newspaper.

Russell-Harrington Cutlery Company of Southbridge represents a merger of the two oldest cutlery manufacturers in the United States: The Harrington Cutlery Company (1818) and the John Russell Cutlery Company of Greenfield (1834). The two firms were united in 1932 under one roof at the present location in Southbridge.

Although the quality of steel in knife blades has been improved by the development of the electric furnace with its delicately accurate controls, there are operations in the making of cutlery where highest quality depends primarily on the hands of skilled craftsmen. In Russell-Harrington's forging room special skills required to form forged blades have been passed down from generation to generation.

The Southbridge firm produces more than 4 million knives annually. Unlike some cutlery concerns which specialize in a few products, Russell-Harrington makes virtually all types of hand knives. It dominates the field in meat-cutting knives for packing houses, supermarkets, hotels, and restaurants. The smallest blade the company makes is a one-inch knife for cutting stencils; the largest is a 17-inch knife for cutting corn stalks.

In Northampton is another large cutlery firm, the Northampton Cutlery Company. This firm's products include stainless steel unmounted blades, one-piece knives, and grass shears.

One of the leading housewares and hardware manufacturers in the state is The Washburn Company of Worcester. This concern, which started as a small business in Boston making screw hooks and screw eyes for the textile industry, is the world's largest producer of outdoor cooking equipment accessories and of bicycle baskets. The company, which has other plants in Rockford, Illinois and in Watford, Ontario, also makes locker baskets and a line of household hardware that includes cup hooks, coat hooks, hammock hooks, curtain rod hooks, eye bolts, ring bolts, screw eyes, screw hooks, and turnbuckles.

Independent Lock Company, which employs more than 1,000 persons in its Fitchburg plants, has the distinction of being the world's largest manufacturer of key blanks and one of the largest manufacturers of locks and builders' hardware.

Boston & Lockport Block Company in Boston, a leading manufacturer of wood and metal tackle blocks, has been at the same location in East Boston for more than 150 years. Numerous small firms in the state specialize in various hardware items such as door knobs, hinges, vises, and fireplace equipment.

An important segment of the metal-fabricating industry in Massachusetts is that which makes bolts, nuts, screws, rivets, and other fasteners. United-Carr Incorporated and its Carr Fastener Division, both with principal plants in Cambridge, rank high among the makers of diversified lines of fasteners throughout the world. United-Carr also has manufacturing facilities in Newton, Burlington, and Wilmington. The total number of its employees in the state approximates 1,500.

The company has been a pioneer in developing special fasteners, serving such important industries as automotive, clothing, and furniture.

Ribbons of steel that will be stamped into razor blades with an edge so fine it would take 750 to equal the thickness of a single sheet of newspaper.

Its operations have expanded until now, besides its Bay State facilities, it has other domestic plants in Chicago, St. Louis, Indiana, California, and New Jersey, three companies in England, one in Canada, and two others in Australia. Currently United-Carr is focusing the bulk of its attention in Massachusetts on the fabrication of metal and plastic components for consumer durable goods manufacturers.

The importance of fasteners to modern living was once epitomized by the founder of another well-known Massachusetts metal-fabricating firm in the following words: "While the screw thread is a simple device, it ties together the whole mechanical skeleton of our civilization." This comment was made by Patrick Sweeney, founder of the Continental Screw Company in New Bedford, in pleading for an international agreement to standardize screw threads. Lack of such standardization had proved a frustrating handicap to the United States, Great Britain, and Canada in coordinating their World War II efforts. British-made nuts would not fit American-made bolts, and vice versa. As Sweeney remarked, "The difference is very slight in dimension, but it could be as wide as the Atlantic Ocean and cause no more trouble." The pleas of Sweeney and others were ultimately heeded in 1948, when uniform international standards were adopted.

The Continental Screw Company which Sweeney established in 1904 in an unheated cotton warehouse has mushroomed into today's six-acre plant in New Bedford, supplying fasteners to manufacturers around the globe. Continental is one of the oldest American companies manufacturing a complete line of fastener products. Besides wood, machine, tapping, and thread-cutting screws, it makes stove bolts and nuts, special ferrous and nonferrous threaded fasteners, and patented products such as thread-rolling screws and self-drilling screws.

In Worcester, the Reed & Prince Manufacturing Company operates from a fifteen acre plant supplying warehousing facilities in strategic distribution points throughout the country. The company manufactures recessed and slotted wood, machine and tapping screws, bolts, nuts, rivets, wing nuts, hanger bolts, cap screws, screwdrivers, bits and other metal specialties of ferrous and non-ferrous metals.

Reed & Prince Manufacturing Company was founded in 1876 to manufacture nails and tacks with machines invented by the Reed family. The original designs and concepts of these machines with subsequent innovations became the basis for the modern high speed cold headers that pour out the billions of fasteners used annually throughout the world. This family trait for inventiveness has passed down through the generations to Edgar Reed, II currently the President of the Company, who holds many patents on screws, screwdrivers and machinery.

In 1938 the company introduced the Reed & Prince Recessed Head Screw, screwdriver and power screw driving bit—a unique combination that offered the important ability in mass production and assembly operations of driving a full range of screw sizes with one screwdriver or bit. The advent of this fastening technique came at a most opportune time and during World War II, large volumes of fasteners supplied to the aircraft industry came from Reed & Prince, helping to speed military aircraft to the far corners of the world.

Today Reed & Prince fasteners are orbiting the earth in space capsules and exploring the ocean floors in nuclear submarines.

In Waltham, the J. L. Thomson Rivet & Machine Company produces a variety of fasteners and machine rivets. Each of these companies has about 600 employees on its payroll.

Supplying small parts to many different industries is a group of nearly 100 Bay State companies engaged in a segment of industry known as the screw machine products industry which is probably the oldest automated industry in the industrial world. Its primary production tool is the automatic screw machine invented in 1873. Components for these machines are made by machining bars of ferrous, nonferrous and plastic base materials automatically fed into these tools. Because these parts are manufactured strictly to customer's specifications and are of precise dimensions, demanding close individual control during production, the manufacturing units of the industry tend to remain small in size. These firms turn out components used in household appliances, in radio and TV sets, in technical and industrial instruments, in firearms, and in all kinds of machinery.

In Worcester alone there are more than a dozen concerns making screw machine products. Some of the larger ones are Olson Manufacturing Company, Parker & Harper Mfg. Co., Inc., and Wright Machine Company. Worcester Taper Pin Co. is nationally recognized as one of the oldest and best known producers of standard taper pins and also manufactures standard dowel pins which are distributed nationally. Large firms in this field elsewhere in the state include Automatic Machine Products Company, Attleboro, 80% of whose production goes into the manufacture of their

own service valves for the air-conditioning and refrigeration industry; Machinecraft Division of Apollo Industries Inc., Whitman; Star Tronics Inc., Georgetown; Ward Machine Company, Brockton; and F. C. Phillips Inc., Stoughton.

More than 100 Massachusetts companies turn out stamped or pressed metal products. These concerns supply metal parts to many industries and make such things as hinges, wastebaskets, pails, trash barrels, jewelry boxes, pens, mess kits, metal cabinets, novelties, and toys.

The Duplicon Company of Westboro, founded in 1945, has grown from a small shop in a barn in Hopkinton to one of the leading short-run stamping firms in the East. The company supplies metal stampings, formed metal parts, and vacuum-formed plastic parts to original equipment manufacturers. Duplicon's products include "stacked metal stampings," resembling the laminated layers of wood in plywood, which for some purposes can be substituted for more expensive machined metal parts.

In Monson, the Eastern Division of Zero Manufacturing Company, which is an important supplier to the aerospace and electronic industries, makes custom sheet metal chassis, housings, shipping containers, racks, consoles, and carts.

Another leader in this segment of the fabricated metal products industry is the Worcester Pressed Steel Company of Worcester. Incorporated in 1904, this company first owned and developed the original patent for deep drawing of metals. Since that time, Worcester Pressed Steel Company has continued to be a leader in developing deep drawing in all metals, plus forming techniques of new exotic materials including titanium, magnesium, and "maraging" steel. Worcester Pressed Steel is a versatile long-run manufacturer of stamping items such as compressor shells, meter housings, filters, pressure vessels and cylinders, paper punches, control boxes and bearing cages. Its complete facilities include a 300-ton six-station transfer press, unique to the geographical region.

Worcester has several major producers of metal stampings, including Killeen Machine Tool Company, Lundquist Tool & Manufacturing Inc., and Parker Metal Goods Company. Most every car and truck on the road has parts which were manufactured by the Larson Tool & Stamping Company in Attleboro. Besides producing components for the automotive industry, Larson also makes parts used in commercial aircraft, in watercraft, and in telephone equipment. Mossberg Pressed Steel Division of Wanskuck Company, also in Attleboro, is another important metal fabricator.

Peter Gray Corporation in Cambridge, which has been a specialist in fabricating metals since it first started making railroad lanterns more than 85 years ago, is primarily a contract manufacturer of stampings, sheet metal sub-assemblies and finished products for other manufacturers. Its engineering capabilities and plant equipment are unusually complete, ranging from the 400-ton capacity of a giant, deep-drawing press down to specialized assembly fixtures and machines.

In addition to its contract work, the company has some captive products. These include automobile license plate frames, which are sold through its Peerless Manufacturing Corporation subsidiary, and storage cabinets for microscope slides, which are sold through its Scientific Research Corporation subsidiary.

In Saugus, another firm with diversified equipment for metal fabrication is the Eastern Tool & Stamping Company. This firm produces sheet metal stampings, dies, and springs. It has facilities for case hardening, tempering, and welding.

At Everett, the Sexton Can Company is a leading manufacturer of metal pails, drums, and barrels. At Taunton the Armor Bronze & Silver Company employs about 450 persons in the manufacture of copper and brass hollow ware gift items. It makes planters, casseroles, tea kettles, and cigarette lighters.

Performing services which provide protection and embellishment to metal surfaces are a large number of small firms scattered throughout the state. These companies have facilities for galvanizing, electroplating, plating, coating, polishing, anodizing, coloring, enameling, etching, and engraving. Most of them specialize in one or two of these processes. Among the metals used for plating are zinc, chrome, copper, nickel, gold, and silver.

Manufacture of metal cans for beverages and foods is a sizable business in the Bay State. American Can Company's plant in Needham, in addition to producing more than 250 million beer and beverage cans also manufactures millions of fibre containers for the milk industry. American Can Company, at its Maynard plant, makes metal squeeze tubes used in packaging various drug store items. Stern Can Company, the oldest and largest independent metal container producer in New England, has recently moved into a new plant in Peabody which has double the space of the Boston plant which the company outgrew. In Malden are two can manufacturers, the New Can Company now heavily involved in the manufacture and

fabrication of perforated metal parts for the automotive industry and for industrial filters and Continental Can Company.

One phase of Continental's operations in Malden is most unusual. Its factory there is situated next door to the bakery of Friend Brothers Inc. and the can company uses an overhead conveyor system which crosses the property line between the two plants to deliver cans directly to the bakery. Producing cans of baked beans and brown bread in Malden is a neighborly enterprise.

Production Tool & Die Company in Springfield makes aluminum foil pie plates.

In the production of valves and pipe fittings Massachusetts has several major companies.

One of the oldest and largest is Walworth Company, which since 1842 has uninterruptedly manufactured valves and pipe fittings. At its Braintree plant, one of the most modern and best-equipped of its kind in the country, the company fabricates a line of products which has won wide acceptance for use in public utility installations and in such important industries as paper, petrochemicals, and shipbuilding.

It was a Walworth Company employee who invented the Stillson pipe wrench, which has been called "America's most famous tool." Daniel Stillson, who took employment with the Walworth firm upon his return from service in the Civil War, invented the wrench in 1869. He wanted to sell his patent rights to his employers for $1,500, but the company's management persuaded him that he would be better off if he let the company manufacture the wrenches under a royalty arrangement. The decision was a wise one. According to Stillson's own calculation, he collected more than $67,000 in royalties before the patent expired.

Worthington Controls Company, second largest manufacturer of control valves in the United States, is a division of Worthington Corporation. It was formed by combining Mason-Neilan of Norwood and the Annin Company of Montebello, California. Mason-Neilan, an outgrowth of Mason Regulator Co., established 1882 in Boston, was acquired by Worthington in 1956 and operated as a separate division. The Annin Company, established in 1947 and purchased by Worthington in 1959, was also a separate division until the merger in 1964. The company employs approximately 900, of which 700 are at the main office and plant in Norwood.

Worthington Controls supplies control valves and certain other control equipment, principally to the petroleum, chemical, aerospace, paper and power industries, as well as to major petroleum and natural gas transmission pipe lines. Its overseas markets are world-wide, supplied through export sales and through licensed manufacturers in England, France, Italy, Germany, Canada, Mexico, Australia and Japan.

In Springfield, the Chapman Division of Crane Company employs more than 900 in the manufacture of industrial valves. The valves, made in all types and sizes, and in a variety of different metals, are used to control manufacturing processes in many industries.

Jamesbury Corp. in Worcester, which in the past decade has grown from four employees to more than 550, claims world leadership in the production of ball valves and controls. In addition to the very many commercial applications, its valves are used on nuclear submarines and in manned space capsules.

Crosby Valve & Gage Company in Wrentham is a leading manufacturer of relief valves. Worcester Valve Co., Inc. of Worcester produces manual ball valves and electrically and pneumatically activated ball valves and components. Other valve and pipe fittings manufacturers include Atwood and Morrill Company in Salem and Standard Fittings Company in Framingham.

Bliss-Rockwood of Worcester, a division of E. W. Bliss Company, manufactures automatic sprinkler

Metal fasteners in a perforated container are dipped in a plating solution for appearance, protection and greater durability.

fire-protection systems, ball valves, and pipe unions. Ball valves, which require only a quarter turn to move from a fully open position to a completely closed position, are becoming increasingly popular in many industrial applications.

Fabrication of structural metal products provides employment for more than 7,000 persons in the Bay State. Of this total, about one-third are engaged in sheet metal work. The more than 100 firms in this line in the state produce heating and air-conditioning ducts, gutters, conductor pipes, culvert pipes, stove pipes, restaurant and kitchen equipment, and fabrications for manufacturers.

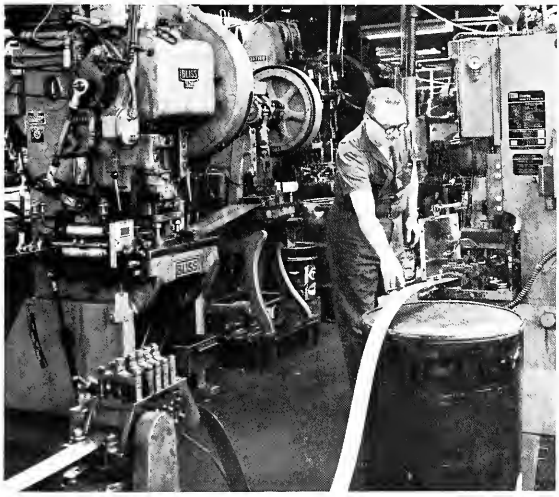
Donnelly Manufacturing Company, a division of J. Brockhouse and Company, has one of the largest job shops in the state engaged in the fabrication of sheet metal to close tolerances. Most of its customers are manufacturers of electronic and computer equipment. The company's plant is in Waltham. Arduini Manufacturing Corporation in Worcester has specialized in precision sheet metal work since 1926, producing a tremendous assortment of products and components.

There are numerous boiler shops in the state producing fabricated plate work such as stills, pressure vessels, industrial processing equipment, weldments, septic tanks, fuel oil tanks, and gasoline tanks.

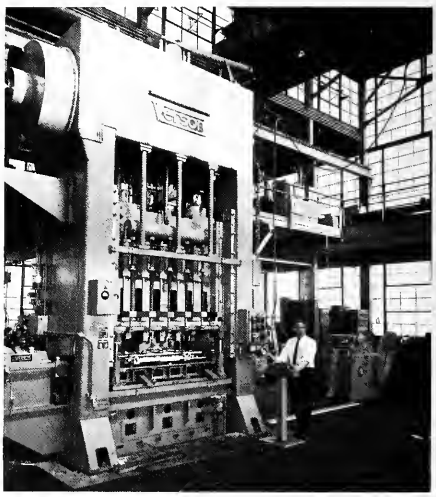
Process Engineering Company of Methuen, whose primary product originally was copper boilers, now designs and manufactures units for transporting, storing, and handling liquid nitrogen and other cryogenic fluids. The company's fabricating division manufactures equipment for the chemical and nuclear industries. This equipment includes heat exchangers, condensers and evaporators. Another division makes expansion joints for use in pipelines that adjust for expansions and contractions due to changes in temperature either in the liquid passing through the pipeline or in the outside environment.

Barnstead Still & Sterilizer Company in Boston makes water purification equipment such as water stills, and demineralizers for hospitals and laboratories. Avery & Saul Co., Inc., in Cambridge, working with steel plates varying in thickness from $\frac{1}{4}$ inch to 16 inches, produces weldments for the machine tool industry. Tower Iron Works Inc. in Seekonk makes stainless steel textile equipment and chemical processing equipment. CPC Engineering Corp. in Sturbridge specializes in steel, stainless steel and aluminum weldments.

Manufacturing plumbing and heating products are a number of Massachusetts companies whose names are well known in these industries. Vamco, Inc. in Springfield is a large producer of plumbing fittings. Symmons Industries Inc. in Boston specializes in shower valves and accessories. The H. B. Smith Company Inc., in Westfield, is a leading maker and the only manufacturer in Massachusetts of cast iron steam and hot water



Thousands of metal parts for industrial and consumer use are produced by stamping various metals into desired forms.



With the use of precision dies massive presses perform several operations on a metal blank at a single stroke.

boilers. Riley Stoker Corporation in Worcester builds steam generating and fuel burning equipment. Sterling Radiator Co. Inc., of Westfield, founded in 1946, has approximately 150 employees in the production of finned tube radiation and covers for all types of commercial and institutional work, baseboard radiation for residences and apartments, gas fired unit heaters, and air conditioning enclosures.

There are nearly 40 concerns in Massachusetts producing fabricated structural steel. Two of the larger firms in this field are located in Cambridge, the West End Iron Works and A. O. Wilson Structural Company. Other large structural steel companies are Haarmann Steel Company in Holyoke, L. Antonelli Iron Works in Quincy, and Tower Iron Works in Seekonk.

Classified as architectural metal work are such things as steel stairs, fire escapes, decorative wrought iron work, flagpoles, railings, steel scaffolding, and window and door grilles. E. Van Noorden Company, founded in Boston in 1873 and now a 4th generation family company, has grown from a roofing and sheet metal plant to one of the largest metal-fabricating companies in the area. With two large plants, each covering about a city block, the firm specializes in such building products as plexiglas skylights, ventilators, louvers, steel stairs, ornamental iron, jail cells, stainless steel food service equipment for hotels and restaurants and pre-engineered steel buildings.

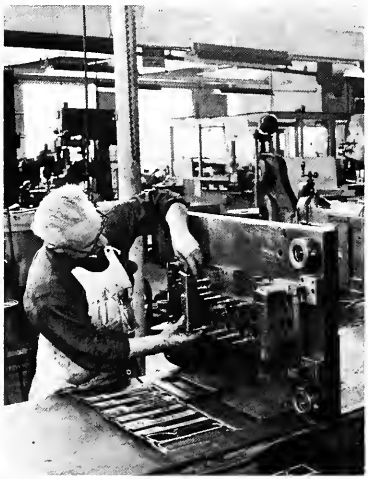
Another segment of the fabricated metal products industry is engaged in the production of metal doors, sashes, and trim. Philipp Manufacturing Company in Easthampton is a large producer of metal doors and frames. In all parts of the state there are companies making aluminum combination storm windows and doors.

Companies fabricating wire products constitute still another group in the industry. Making such products as wire netting, wire cloth chain link fencing, steak broilers, dish racks, and tire chains, these concerns provide jobs for some 1,800 Bay State workers.

In smoky shops under spreading chestnut trees, the mighty muscles of early blacksmiths shaped the first machine parts and tools on red-hot roaring forges and resounding anvils. As the industrial revolution picked up speed, visionary men developed the steam hammer, faster metal-cutting tools, lathes, taps and dies, all designed to improve production techniques and facilities.

Demand and supply existed side by side in Massachusetts. Strides in manufacture were equally paced by metal fabricators developing component parts, tools, and equipment. There may be a dispute as to whether Charlie Monckey or Solymon Merrick first conceived the "Monkey" wrench in Springfield but the fact remains that, still today, Massachusetts ingenuity can meet Massachusetts demand.

A round stainless steel rod, heated to 2000°F., is forged into a knife blade under a 1000 pound drop hammer.



The manufacture of precision dies for bending, forming and piercing metal is an important step in metal fabrication.

The Machinery Industry

Yankee ingenuity develops the state's number one product

In the days when papermaking was a hand operation, one of the earliest mills in Massachusetts had a work force consisting of the boss and four employees. By working 10 hours a day and a six-day week, this mill could produce 720 pounds of paper in a week. Today, a single machine, operated by four men, can make that much paper in 12 minutes. This illustration from the paper industry is only one of many that might be cited to indicate the tremendous increase in our ability to produce resulting from the use of machinery.

In every industry, machines have been developed to save labor, increase production, and reduce costs. The economy of plenty which we enjoy in America today is largely due to machines.

Yankee ingenuity has played an important part in the development of these machines. Some of the greatest inventions were made by geniuses who were born in the Bay State. Others were the brainchildren of people from other states and other lands whose principal experiments and discoveries were made while they were living in Massachusetts.

Eli Whitney, inventor of the cotton gin, Elihu Howe, inventor of the sewing machine, and Samuel Morse, inventor of the telegraph, were all natives of the Bay State. Whitney was born in Westboro, Howe in Spencer, and Morse in Charlestown. Another Morse, Stephen A. Morse of West Bridgewater, was the inventor of the twist drill.

Two of the inventive geniuses in the electrical industry conducted their experiments in Massachusetts. William Stanley, a native of Brooklyn, New York, invented the transformer while living in the Berkshires, and the English-born Elihu Thomson amassed his collection of more than 700 patents while working for General Electric Company of Lynn.

Today, machinery is built in Massachusetts for several major industries including paper, automotive, metalworking, woodworking, textiles, shoes and leather, food, plastics, and chemicals. Massachusetts firms make turbines, generators, and electrical equipment to supply the power to run these machines.

Actually, machinery is the state's Number 1 product. The making of machinery provides more jobs than any other industry and brings in more dollars to the state's economy. The industry is so large and varied that it cannot be covered adequately in a single chapter. In Massachusetts the electronics companies, often classified as part of the "electrical machinery" industry, represent such an important group by themselves that their operations are described in a separate chapter in this book. In this chapter we are concerned strictly with machinery that is electrical and with machinery other than electrical or electronic (sometimes referred to as "nonelectrical").

Excluding some 68,000 employed in electronics, there are about 96,000 persons on the payrolls of the other machinery firms in the Bay State. Of these, another 68,000 are in the nonelectrical segment and 28,000 in the electrical.

Machinery made in Massachusetts, both electrical and nonelectrical, enjoys a worldwide reputation. It is shipped to the four corners of the earth.

Steelmaking, Machine Tools and Allied Equipment

In every major country in the world, for instance, there is heavy steel mill equipment designed and built by the Worcester firm of Morgan Construction Company. This company was founded in 1888 by Charles Hill Morgan, who in that year engineered and built the first American-designed continuous steel rolling mill. This mill, installed at the Cleveland plant of American Wire Co., incorporated inventions of Morgan. These incorporations substantially improved a continuous rolling mill of British design which had been used in this country.

Earlier, Morgan had designed machinery to make helical wire springs and had established the Morgan Spring Co. in Worcester. He formed the Morgan Construction Company to design and build wire drawing machinery for his spring company and for other firms in the wire business.

Since its establishment, Morgan Construction Company has designed and built more than 250 continuous rolling mills. These mills are multimillion dollar units, requiring between one and two years to be designed and manufactured. Consisting of furnaces, the mill proper, and a product handling

area, each unit occupies an entire mill building.

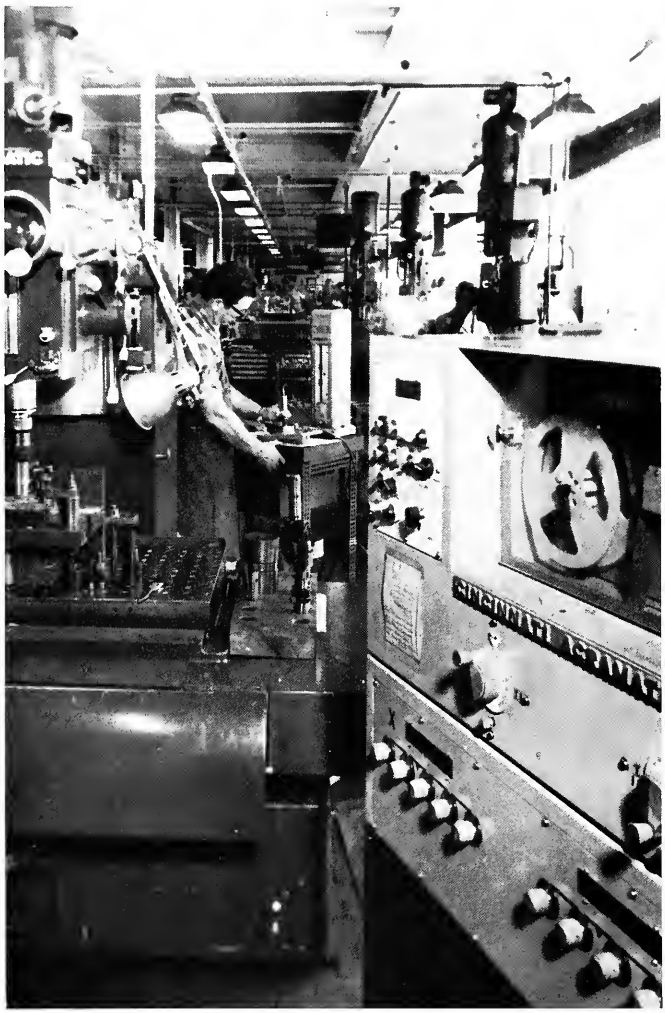
Charles Morgan's inventive genius was not confined to machinery for the steel industry. Early in his career he invented a machine for making paper bags, and for two years he and a brother ran a successful paper bag business in Philadelphia.

Today, besides rolling mills, Morgan Construction Company makes wire drawing machinery, a furnace control system for melting and heating the ingredients of steel and glass, and flood-lubricated precision bearings.

The Morgan firm stands alone in Massachusetts as a builder of rolling mills for the basic steel industry. But in the production of machinery to cut and shape steel and other metals, or machines for metalworking, the state has a long list of nationally known companies. Included in this group are the makers of machine tools and machine tool accessories. Also included are numerous producers of dies, jigs, and molds. In all, there are well over 400 Massachusetts firms in this broad field.

In simplest terms, a machine tool is a power-driven tool used to cut or shape metal. The National Machine Tool Builders' Association once offered a more precise definition: "a power-driven complete metalworking machine not portable by hand, having one or more tool or work holding devices, and used for progressively removing metal in the form of chips."

Among the functions performed by machine tools are drilling holes,



Programmed machining through the use of punched tapes produces machine tool parts with the utmost accuracy and uniformity.

reaming, shaping, planing, and grinding. They do the work which the hand craftsman accomplishes much more laboriously by chipping away at the metal with such tools as files and chisels.

A Massachusetts machinery builder whose machine tools are sold in every country in the Free World is the Heald Machine Co. of Worcester. This firm, now an associate company of The Cincinnati Milling Machine Co., is a leading manufacturer of internal and rotary surface grinding machines, precision boring machines, and numerically controlled machining centers. It employs 1,800 persons in its big plant in Worcester.

The company was founded in 1826 in the town of Barre by Stephen Heald. His principal business at the start was repairing ox yokes, sleighs, plow beams, and farming tools. Later he made cheese presses and wire drawing machinery.

For more than 70 years, the Heald Machine Co. remained a small company operating in the rural atmosphere of Barre. Its move to Worcester in 1903 came under dramatic circumstances.

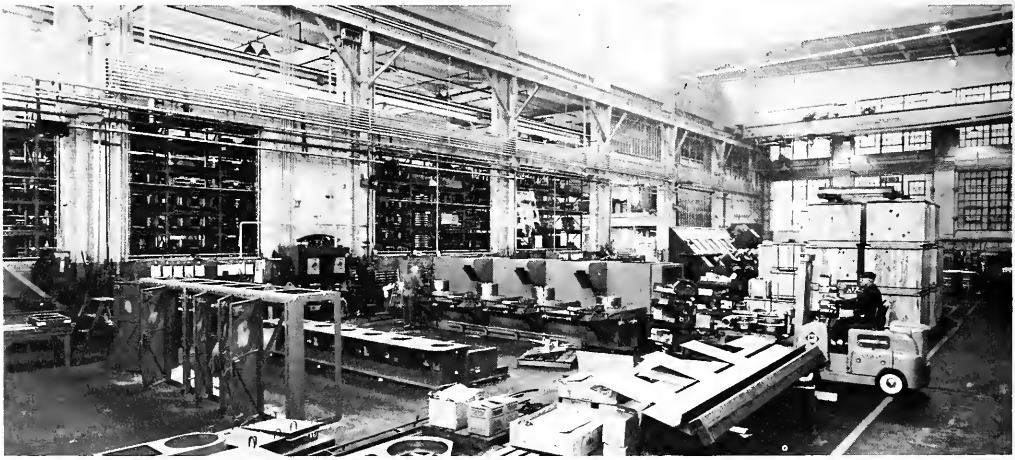
James N. Heald, grandson of the founder, wanted to buy the machine shop part of the business from his father and move it to Worcester, where he felt the opportunities for growth would be greater than in Barre. His father didn't like the idea but he reluctantly gave his son an option to buy the business if he could produce $10,000 in cash by a certain day.

James worked diligently trying to interest Worcester people to invest in his project. He got substantial support, but when the day for expiration of the option dawned he was still short of the required $10,000. On the final day he raised the amount he lacked. He then induced a friend who had a pair of fast horses to drive him to Barre, where he delivered $10,000 in gold to his father. He acquired the business and moved it to Worcester.

Expansion of the business in Worcester was helped by the growth of the automobile industry. James Heald designed a rotary surface grinder for grinding piston rings and an automotive cylinder grinder. Later, several types of high production internal grinding machines were developed and the company became firmly established as a leader in its field.

Another Worcester firm which is an important producer of grinding machines is the Norton Company. Firm in his belief that initial cost should be measured only by final result, Charles Norton came to Worcester in February of 1900. With him he brought the plans for his revolutionary grinding machine which he presented to the officers of the Norton Emery Wheel Company. As a result, on February 27, 1900, the Norton Grinding Company was formed. One morning the following November, the first production cylindrical grinding machine, designed by Charles Norton, was completed for grinding printing press rolls.

Revolutionary in every respect, the machine weighed 13,000 lbs., its size was 18 inches by 96 inches, and it used a wheel 24 inches in diameter and 2 inches thick (four times as large as any former wheel). Its



Wire is drawn to size over reels that wind on the wire at many hundreds of feet per minute. Illustrated is a multi draft wire drawing machine being assembled.

work speed was increased considerably and its cutting action was sixteen times more efficient than any other machine then in existence. Its feed mechanism was so accurate that it served as a micrometer, making possible unparalleled precision.

In time, this method of grinding was adopted in almost every operation of automobile manufacture. It was the steel crankshaft, the backbone of the engine, however, which first claimed the attention of Norton grinding experiments in 1903. It was discovered that in about 15 minutes the Norton grinder would do as much work as that previously accomplished in five hours of turning, filing, and polishing. It was a great day when Ford Motor Company purchased 35 machines.

By 1918 the Norton Grinding Company was making 40 types of machines, with more than 180 modifications. On June 24, 1919, the two companies were merged as the Norton Company. Today the Machine Tool Division is a multimillion dollar business which is a vital part of the Norton Company complex. It produces a complete line of cylindrical, centerless, tool room, and special automotive grinders. Additional machines include lappers, gear hobbers, and semiconductor machines for dicing and wafering electronic devices. All these machines are shipped to all parts of the world.

The Lapointe Machine Tool Company of Hudson is the world's oldest and largest manufacturer of broaching machines and related equipment. Lapointe pioneered broaching. The company was founded in 1902. Until that year most machining of metal parts had been carried out by manual means, using old type simple operation machines. J. N. Lapointe devised the idea of removing metal by keyway cutting. After much trial and error, Lapointe hit on the idea of a screw type key seater. Now by cutting several teeth on a rod, and by using this rod in a drill press, Lapointe discovered that he could push the rod through the workpiece and so obtain the same result as if he had hammered through a number of single punches to make the hole. Thus, in essence, broaching was born. Today, Lapointe offers the most complete line of broaching machines and tools in the world. Lapointe equipment serves the needs of manufacturers of automobiles, trucks, farm equipment, tractors, sporting goods, and cameras, to name but a few. Headquartered in Hudson, Lapointe also has manufacturing facilities in Mountain View, California, Watford and Bracknell, England.

Van Norman Machine Co. in Springfield, a division of Universal American Corp., builds milling machines and various types of grinders. It also makes a complete line of equipment for rebuilding automobile engines, including crank and camshaft grinders, cylinder head and block refinishers, and brake drum lathes.

Blanchard Machine Co. of Cambridge, a division of Pneumo Dynamics Corp., pioneered in the development of vertical spindle rotary table type grinders, widely used for the grinding of flat surfaces. The Cambridge firm is the largest manufacturer in the country of this type of grinder.

Reid Brothers Co. in Beverly is another manufacturer of grinders. This firm made the first frozen food machines for Birds Eye. It also made the first coin counting and sorting machines.

Other machine tool builders in the Bay State include Chas. G. Allen Co., Barre, drilling and tapping machines; Leland-Gifford Co., Worcester, drilling, tapping, and boring machines; and Rivett, Inc., Boston, toolroom lathes and grinders.

Tubular Rivet and Stud Division of Townsend Co. in Braintree is one of the largest producers of tubular rivets and rivet-setting machines. Its rivets, made of steel, brass, copper, or aluminum, with some being made of silver, are widely used as fasteners in electrical appliances, TV sets, radios, and telephone receivers. They are widely used in the automobile industry for such purposes as fastening windshield wiper blades and brake shoes. Some of the company's rivet-setting machines can set as many as 11 rivets at one time.

"Machine tools" is a somewhat misleading term. "Machines to operate tools" might be a more accurate description. The machine takes the place of hand labor, but, like the hand craftsman, it must have tools to actually cut the metal. Making these special tools for machine tools is an important segment of the machinery industry in Massachusetts.

Greenfield Tap & Die Division of United-Greenfield Corp. has been in the business of making taps (tools for cutting internal threads) and dies (for cutting external threads) for almost a century. The original firm of Wiley & Russell started production in 1872 in a small factory on the site of the present plant in Greenfield. In 1912, Wiley & Russell merged with several of its larger competitors into the Greenfield Tap and Die Corp., forming the world's largest manufacturer of threading tools.

Besides taps and dies, the company, which merged with United Drill & Tool Corp. in 1958, manufactures gages, drills, reamers, "end

mills" (a type of cutter used in milling operations), and other tools.

UTD Corp., formerly Union Twist Drill Co. of Athol, is one of the largest manufacturers of cutting tools in the country. It makes twist drills in a great variety of types and sizes, reamers, milling cutters, end mills, taps, dies and hobs (tools which cut gear teeth).

Besides its operation in Athol, UTD has two other plants in Massachuetts. In Holden, its subsidiary, the Reed Rolled Thread Die Co., manufactures machines and dies used in a relatively new process of "chipless" machining. In this process, threads are produced by a rotary motion and pressure rather than by cutting the metal. The company has been a pioneer in the development of this process.

Another UTD subsidiary in the Bay State, Merriman Brothers Inc., for many years located in Boston, is known to yachtsmen as a producer of quality marine hardware. The company, which has recently erected a new plant in Hingham, has expanded into other fields. It makes powdered metal products and it manufactures self-lubricating expansion plates and bushings which are being increasingly used for bridges, buildings, and large industrial installations, such as refineries and self-lubricating spinning and twisting rings for the textile industry.

The total payroll of UTD Corp. in its three Massachusetts plants numbers 1,600. A complete line of cutting tools foi machine tools is produced at the New Bedford plant of Morse Twist Drill Co., which has been manufacturing tools in that city since 1864. The founder of this company, Stephen A. Morse of West Bridgewater, invented and patented the first twist drill in 1863. One of the leaders in the industry, the company's line includes drills, reamers, milling cutters, end mills, taps, and dies. The firm, now a division of Universal American Corp., employs 1,200 persons.

In Greenfield, Threadwell Tap & Die Co., a subsidiary of the Sheffield Corporation of Dayton, Ohio, and an affiliate of the Bendix Corporation of South Bend, Indiana, manufactures products for the machine tool, cutting tool, and gauging fields including drills, taps, keyway broaches, end mills, and counterbores. In Mansfield, Bay State Tap and Die Division of The Cleveland Twist Drill Co. produces cutting tools for threading metal. John Bath & Co. Inc. in Worcester makes ground thread taps and thread gages. In Watertown, the Van Keuren Co. makes precision measuring tools.

Manufacturing with machine tools involves the use of jigs, fixtures, and gauges. A jig is a combination work-holding and tool-guiding device used principally in drilling operations to insure accuracy and uniformity in drilling.

A fixture performs a similar function in positioning the work for "surfacing" types of machine tools such as milling machines, planers, and shapers.

Gauges are precise measuring devices which are used to make sure that the machine is producing parts which meet the exact specifications of the designer.

Jigs, fixtures and gauges were unheard of when things were made by hand. The coppersmith made tea kettles one at a time. The kettles varied in size, so did the handles. Today kettles and handles must all be exactly the same size. The parts must be interchangeable in mass production.

Credit for the development of a system of manufacture which produced interchangeable parts goes to a native son of Massachusetts, Eli Whitney, inventor of the cotton gin. Failing to realize the profits he had expected from his invention of the cotton gin, Whitney turned to the manufacture of firearms. Making his own jigs, fixtures, and gauges, the inventor was able to produce muskets whose parts were completely interchangeable. When he showed his muskets to military officials, the advantages in having weapons which could be easily repaired on the field were so obvious that he was awarded a big contract by the United States Government.

Today uniform parts for all kinds of mechanisms are produced automatically by machines which cut and shape the metal in exact conformity with the pattern of a die.

The word "die" has many different meanings in metalworking. There are thread-cutting dies, such as those mentioned previously, and there are casting dies which are molds into which molten metal is forced for shaping. Dies are necessary, too, to produce parts which are stamped out of sheet metal by automatic machinery.

In metal stamping, the moving part of the die, called the punch, strikes the metal and forces it against the stationary part of the die, called the matrix. Engraved in the surface of the matrix is a cavity of the exact shape of the desired part. The punch forces the metal into this shape.

Making precise dies for this type of work requires skill and time, but once the die has been made it can be used to produce millions of accurately shaped parts automatically.

In Massachusetts there are well over 200 firms engaged in the business of making dies, jigs, and fixtures. Many of these operate their own machine tools to produce finished parts for industrial customers, besides supplying dies and jigs to

manufacturers in many different industries.

Plastic products are made with machinery built in the Bay State. Several Massachusetts firms build molding machines for the fabrication of plastic products, including Lombard Industries Inc. in Ashland, the Reed-Prentice Division of Package Machinery Company in East Longmeadow, Springfield Cast Products Inc. in Springfield and Standard Tool Company in Leominster.

Cumberland Engineering Company in Attleboro makes a broad line of plastics granulating, pelletizing, and dicing machines. Hobbs Manufacturing Company in Worcester produces extruders, haul-off, and winding equipment for the plastic film and sheet industry. Numerous Bay State firms make molds for plastics.

In Malden is the W. E. Arnold Co., Inc., which is the oldest firm in the country making steel and aluminum molds to make rubber heels and rubber soles for shoes. The important role Massachusetts has played in the development of machinery for the manufacture of shoes is described in the chapter covering the shoe and leather industry.

Textile Machinery

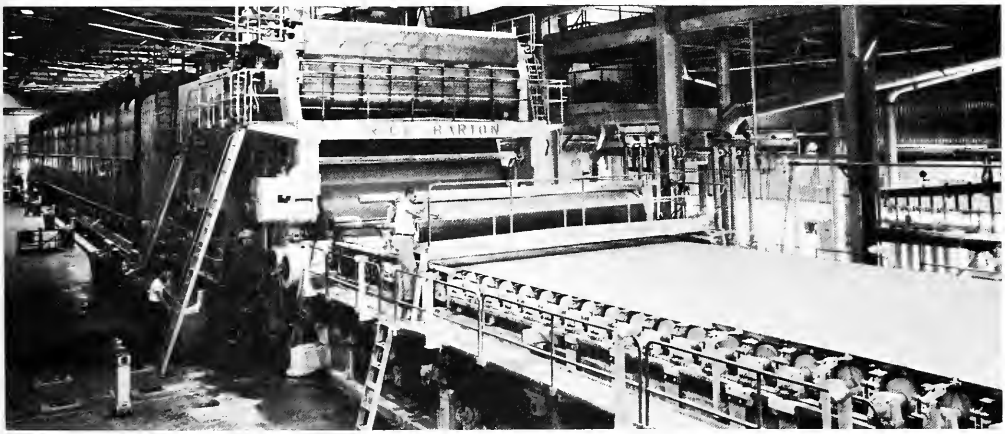
In the field of textile machinery, the Bay State has maintained a preeminent position for many generations. Machines built by such long-established firms as Draper Corporation, Whitin Machine Works, and Crompton & Knowles Corporation are installed in textile mills around the world.

Draper Corporation traces its history back to the year 1816, when Ira Draper obtained a patent covering his invention of the first self-acting loom temple. A temple is an attachment to a loom which keeps the cloth stretched during certain phases in the weaving process. The type of temple used before Draper's invention required frequent adjustment. With the Draper device production was tremendously increased, since it made it possible for a weaver to run two looms instead of one. This invention, which came just at the time when power looms were first being introduced in this country, became the foundation of the business of Draper Corporation. It was the first of many improvements in textile machinery which the company has sponsored in its long history.

Today, at its big plant in Hopedale, the Draper firm makes both conventional looms with shuttles and the newer shuttleless looms. It is the world's largest builder of automatic looms, shipping to all parts of the globe. The company's catalogs are printed in Spanish, Portuguese, French, German, and English.

Whitin Machine Works, leading builder of textile preparatory machinery, also got its start as a result of an important invention. John C. Whitin, working in his father's small cotton mill, saw the need for a machine to clean cotton as it came from the bale. In 1831 he invented what he called a "pick and spreader," the first cotton-cleaning device to perform satisfactorily. Demand for his machine was so great that Whitin gave up his mill work to go into machinery business.

From the "pick and spreader" of the early days, the Whitin company has expanded to the manufacture of a complete line of preparatory machinery for all kinds of fibers

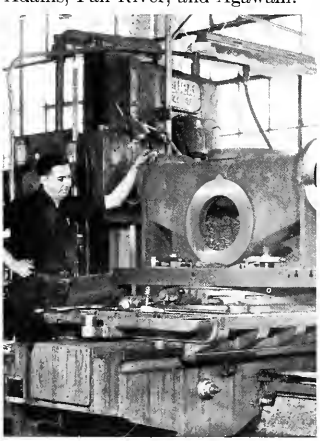


Pulp is transferred into paper at 2,500 feet per minute on this Fourdrinier machine weighing 2,400 tons and costing more than $3,000,000.

including cotton, wool, and synthetics. This company makes every kind of machine required to process fibers from the time of their arrival in the raw state to their production as finished yarn, ready for weaving or knitting. The company's plant in Whitinsville comprises 32 buildings and has manufacturing floor space totaling about 50 acres. It has a payroll of over 3,500.

Since World War II, the Whitin firm has diversified into non-textile fields. It has acquired businesses in Maine, New Jersey, and Pennsylvania, and its product list now includes printing presses, foundry type, office duplicators, shoe repair machinery, machine tools and food processing equipment.

Crompton & Knowles Corporation is the world's largest manufacturer of fancy or box multiple-shuttle looms for the weaving of complex-patterned fabrics. The company, which has diversified into several fields besides textile machinery, operates plants in half a dozen states. In addition to its main plant in Worcester, it has manufacturing facilities in North Adams, Fall River, and Agawam.



Special tooling is required for machining complicated parts to precise specifications.

The company's origin can be traced back to 1840, when the manufacture of looms to weave fancy woolens was begun in Worcester. These looms utilized the concepts and patents of William Crompton, who came to this country from England in 1836. Several nineteenth century family enterprises, including the Crompton Loom Works and the Knowles Loom Works, were incorporated as the Crompton & Knowles Loom Works in 1897.

For many years the firm concentrated on the production of weaving machinery to produce a wide range of fabrics: from tapes less than half an inch wide to papermakers' felts in excess of 60 feet wide. In 1953, the company embarked on a diversification program. Now about 40 per cent of its total volume of business comes from products other than textile machinery.

In 1962, the company acquired the century-old James Hunter Machine Co. in North Adams, which manufactures textile finishing equipment. Earlier it had purchased the Carl N. Beetle Plastics Corp. in Fall River which manufactures custom-molded items of fiberglas reinforced plastics. The company has acquired several firms making packaging machinery, including the Wrap-King Corporation of Holyoke, and it has facilities in Agawam producing this type of machinery.

Davis & Furber Machine Company, North Andover, was founded in 1832 for the purpose of designing and building woolen system textile preparatory and yarn-making machinery. The company's lines of product have broadened in the textile machinery field, but the concentration remains in woolen and worsted system machinery and accessories which are distributed on a world-wide basis.

Curtis & Marble Machine Co. in Worcester, founded in 1831, makes several types of machinery for handling fabrics in the so-called "cloth room" of a textile mill. This machinery, used at a stage in the process between weaving and bleaching, includes winding and measuring machines, folders, re-rolling machines, scrays (where loom rolls are sewed together), and shearing machines.

In Taunton, the Mount Hope Machinery Co. is the world leader in the research, design and manufacture of web controls, which are used not only in the textile industry but also in the paper and plastic film industries. The firm has three manufacturing plants in the U.S., one in Canada, and affiliate companies in England and Switzerland.

Another versatile Massachusetts machinery builder is the Rodney Hunt Machine Co. in Orange. This firm makes bleaching ranges, dyeing kettles, and other finishing equipment for the textile industry. In the field of water control, Rodney Hunt Co., which more than a century ago was building wooden water wheels for New England mills, manufactures sluice gates, operating mechanisms, and related equipment. The company's Industrial Rolls Division makes a wide range of specially designed rolls for processing paper, textiles and plastics.

Parks-Cramer Company, Fitchburg, founded in 1872, are pioneers and specialists in the design, manufacture and installation of textile mill air conditioning equipment. This includes traveling automatic blowing and vacuum cleaners for keeping yarn and cloth-making machinery, material in process and rooms lint-free.

Card clothing machinery, used in the processing of all types of textile fibers, is made by several Bay State companies. Leaders in this field

include Ashworth Bros. Inc. in Fall River, Howard Bros. Mfg. Company in Worcester, and Redman Card Clothing Company in Andover.

Massachusetts-made machinery is also widely used in the making of garments. Reece Corporation in Waltham is the leading builder of automatic buttonhole sewing machinery. The Waltham firm also sells to the apparel industry automatic machines to sew on labels and welt pockets, and tacking machines to reinforce the points of strain in apparel. The first Reece machine was one of the first steps toward automation in the apparel industry and aided that industry to mass produce its products. While the operator inserted the fabric, the machine performed all of the complicated operations previously done by hand methods. Founded in 1881, the company was among the very first to offer its equipment to customers on a lease basis.

About 80 companies in the Bay State produce machinery for the textile industry. Among the larger companies are H. F. Livermore Corporation, Boston; Machinecraft Inc., Whitman; Abington Textile Machinery Works, North Abington; David Gessner Company, Worcester, and Mossberg Pressed Steel Division of Wanskuck Company, Attleboro.

Papermaking Machinery

In the manufacture of machines for the paper industry, Massachusetts has a long record of technical achievements. It was on equipment built by the Jones Division, Beloit Corporation, now located in Dalton, that newsprint from wood pulp was first produced in America in 1867. A century later, this company is still developing new ideas for pulp and paper processing. Quite recently the firm introduced a new machine for converting sawdust, chips, and other wood waste material into usable fiber for making paper.

The Jones Division got its start in 1845 in a small machine shop in Lee. Besides several paper mills, the town has the Clark-Aiken Co., manufacturers of a broad range of machinery for papermaking. Its products include pulp mill machinery, sheeters, knives, slitters, and materials handling equipment.

Henry Fourdrinier's machine to make paper in a continuous roll revolutionized papermaking early in the nineteenth century. Today, Rice Barton Corp. of Worcester builds huge Fourdrinier machines which can transform pulp into paper at amazing speeds. The Worcester firm has been building this type of machinery for nearly 140 years, and its Fourdriniers have been installed in paper mills in all parts of the country. One of the most recent machines built by Rice Barton is designed to produce paper 260 inches wide at the rate of 2,500 feet per minute.

In Walpole, the Bird Machine Company was organized by owners of the Bird & Sons paper mill. It was this company's job to manufacture a German-designed screen for papermaking. This company has since expanded from this one product to the manufacture of some 25 types of machinery and equipment for paper mills and other industries. In addition to paper machinery, the firm makes machines which separate solids from liquids. This process is important in the chemical and mining industries. This company also builds machinery for the recovery of huge volumes of industrial wastes and sewage that would otherwise pollute water supplies.

How Bird Machine Company, which hitherto had built machinery exclusively for the paper industry, became a leading builder of equipment for the broad field of chemical processing and waste recovery is an interesting example of Yankee enterprise and foresight. Early in its history, the company inaugurated a policy of licensing manufacture and sale of its paper machinery to manufacturers of similar specialties in foreign countries. In return, the company secured similar rights to manufacture and sell machines developed abroad. Among the products developed in Europe was a machine for removal of tiny particles of grit, metal, and rubber from paper pulp by employing centrifugal force.

Bird Machine Company not only developed machinery utilizing this principle for leaning up pulp and paper stock, but also for all industries and public utilities dealing with solids suspended in liquids. Today, Bird equipment for centrifugal separations of solids from liquids is used around the world. With the growth of its business, the Bird firm has repeatedly expanded its Walpole plant, which now employs about 500 persons.

Also located in Walpole is the L. F. Fales Machine Company, founded in 1894 by Mr. Lewis Fales, who in 1930 willed $100,000 to the town to establish the Charles Fales Scholarship Fund. One of the early products produced was the Fales multiple needle sewing machine to sew horse blankets. Today Fales is the leading builder of large multiple needle sewing machines for stitching automobile upholstery, mattresses, furniture upholstery, and insulation batting. The major automobile manufacturers and others have many of the Walpole-made machines in their plants both here and abroad. Fales also makes machines to slit and rewind paper at speeds up to 1,000 feet a minute. These machines are used to slit

paper into narrow widths for such products as soda straws, ticker tape, punched tape for numerically operated equipment, and insulation for electric wires and cables. Fales slitters are standard equipment in many of the largest plants in this country which slit and rewind paper in widths of 2 inches or less.

Bolton-Emerson, Inc. in Lawrence makes various types of machines that prepare pulp for papermaking. These include machines to refine the pulp and treat the fibers so they will absorb water. One of the company's products is a magnetic separator which removes from the pulp mixture any foreign metal object which might damage the papermaking machinery. It is not uncommon, particularly where waste paper is used in pulp, for quite sizable metal objects to get mixed in with the material. Even horseshoes have been found in batches of pulp. The Lawrence firm also makes showers for cleaning the wires of papermaking machines and knives for cutting finished paper.

One of the important processes in finishing paper involves running the paper through a series of rolls in a machine called a calender. This calender is also adapted to the textile industry. In Holyoke, the B. F. Perkins & Son, Inc. plant manufactures calenders of all sizes for both the paper and textile finishing industry. This Holyoke concern has the largest installation of presses in the world. These presses are used in manufacturing the rolls for these calenders. The rolls are made of compressed cotton and paper. An exclusive product of the Perkins firm is the Mullen Tester which is used both here and abroad as the standard burst test of paper, paperboard, and allied materials.

Most of the groundwood pulp mills in the country use pulp grinders made by the Montague Machine Co. of Turners Falls. Lodding Engineering Corp. in Auburn specializes in precision equipment for the paper industry. Its products include "doctors," blades and showers.

Two Bay State companies are important producers of machinery for making paper boxes. The Post Machinery Division of Reid Brothers Co. in Beverly makes high-speed machines for folding and gluing paper boxes, machines for folding and heat sealing plastic-coated cartons for milk and other foods, and machines for applying wax and other coatings to boxboard. Thompson National Press Co. in Franklin makes cutting and creasing presses for paper boxes.

In Lawrence, two long-time concerns produce specialized equipment for the paper industry, J. H. Horne & Sons Co. and Hamblet Machine Company.

New and better methods of manufacturing are constantly being developed for the paper industry. In addition to the improvements which the machinery builders are continually introducing in their machines, individual manufacturers in the industry often make important contributions to technical progress. An example of this is the dielectric drying system developed by the Fitchburg Paper Co. This system reduces the moisture content of paper by creating heat in the material itself, instead of the conventional method of applying heat from outside sources. This technique has created widespread interest, not only in the paper industry, but also in other industries with drying problems.

Machinery for the Food and Packaging Industry

The food industry turns to Massachusetts for much of the automatic machinery it uses both in processing and in packaging its products. Every meal you eat probably includes items which have been processed or packaged by Massachusetts-built machines.

J. W. Greer Company in Wilmington is the largest manufacturer of confectionery equipment and the largest manufacturer of blast freezing equipment in the country. The firm is also a leading producer of baking equipment.

This concern was founded in 1917 by Jesse W. Greer, a Texan who had patented a method of cooling chocolates and hoped to introduce his idea to the candy industry centered in Boston and Cambridge. Greer had only $500 with which to launch his venture when he came to Massachusetts. On this small capital he established the business which has since sold millions of dollars worth of machinery to food processors throughout the world.

The Greer firm has greatly expanded. It has produced machines for coating chocolates. It has developed automatic ovens to produce biscuits, cookies, and wafers. It makes machines to produce a wide variety of frozen foods. One of these batters, breads, fries, cools and freezes cut pieces of chicken automatically at the rate of more than 30 pounds a minute.

Manton-Gaulin Manufacturing Company in Everett is the world's largest builder of homogenizers. This machine breaks up the fat globules in milk into small globules 1/200th to 1/500th the size of those in unprocessed milk. Consumer acceptance of homogenized milk in the United States was the result of a joint research effort of the Manton-Gaulin Manufacturing Company and the Children's Hospital, Philadelphia, Pennsylvania. After four years of extensive hospital case testing and

evaluation, homogenized milk was definitely approved for consumption by children. Release of the study was made in 1937 and from that date on, the use of homogenized milk steadily increased. More than 90 per cent of all fluid milk is homogenized. This homogenizer is used in processing other foods such as baby foods, catsup, cheese, chocolate syrups, fruit juices, ice cream mixes, salad dressings, soups, and sauces. The homogenizer is utilized extensively in the industrial world for products such as adhesives, cements, grease, hand creams, paper coatings, pharmaceuticals, pigments, wax emulsions, and innumerable other industrial products. Manton-Gaulin is also a leader in the manufacture of sanitary high-pressure pumps for spray drying of dairy and food products.

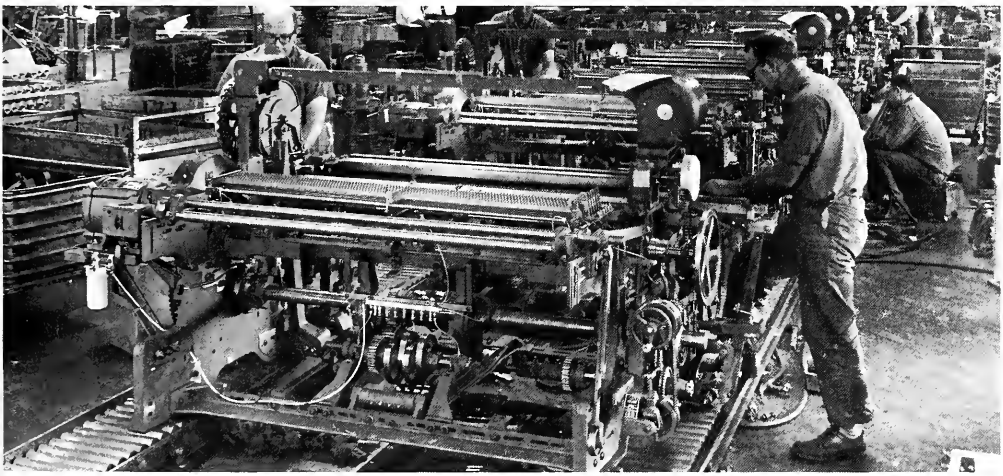
In the shadow of famed Faneuil Hall in 1897, a small forge shop was formed which has become the Market Forge Company, a major metal fabricator and a leader in many commercial and institutional industries. Cooking equipment for restaurants, schools and other large kitchens, hospital equipment of stainless steel, and shelving systems for many uses are made here. Market Forge, a diversified organization, also makes automobile top luggage carriers, seat belts, ski and other sporting items in its expanding Everett plant.

The Carver Cotton Gin Company, a division of The Murray Company of Texas, Inc., in East Bridgewater, is the largest builder of machinery for delinting and hulling cottonseed. This machinery is used preliminary to the extraction of the oil. Elezear Carver, a Bridgewater mechanic, saw the Eli Whitney cotton gin and began shortly thereafter to perfect a commercial machine in Natchez, Mississippi. He returned to Bridgewater in 1812 to start manufacture there and moved to the present plant in 1842. Only cottonseed machinery is now produced and a large portion in recent years has moved into the export field as cotton growing has developed abroad.

Other Massachusetts companies supplying processing equipment to the food industry make automatic slicing machines, vegetable peelers, meat tenderizers, frozen fish processing equipment, potato chip machines, bottle shaking machines, and ice cream freezers.

Making machinery for automatic wrapping and packaging of foods are several large concerns in the Bay State. One of the oldest firms is Pneumatic Scale Corporation Ltd., founded in 1895, which has its main plant in Quincy. It makes more than 100 different machines for automatic bottling and packaging. Bottling machinery made in the Quincy plant includes automatic units to fill containers with liquids or powders and machines for capping and labeling the containers. These machines, which can be used for glass, metal or plastic containers, operate at high speeds. One of the company's liquid fillers can fill bottles at a rate up to 480 bottles a minute. Packaging machinery made by Pneumatic Scale includes machines for carton forming, lining, filling, top closing, and tight wrapping.

A Massachusetts company which



Massachusetts has long been a leader in the manufacture of looms shown here moving along a convevor assembly line.

has developed machines to package everything from cigarettes to bullets is Package Machinery Company in East Longmeadow, whose broad line of packaging equipment includes many machines used by food processors. It makes for the bread-baking industry, for example, a slicer-wrapper which cuts bread into toaster-size slices, wraps the loaf, heat-seals the seam, and applies end labels, all at the rate of 90 loaves a minute!

Package Machinery Company has pioneered many developments in packaging. In 1919, the firm brought out a machine to wrap cigarette packets in glassine paper to preserve freshness, and ten years later it revolutionized cigar merchandising by introducing a machine to wrap cigars in moisture-proof cellophane. More recently, it developed machines to wrap chewing gum and other products in packages with easy-opening tear tapes. In the food industry one of its achievements was the designing of a machine to provide sanitary protection for the tops of milk bottles by capping them with a hood-type cap covering the entire lip of the bottle.

In Worcester, the Worcester Division of Geo. J. Meyer Manufacturing Company is the world's largest producer of high-speed labeling machinery and is a major producer of other packaging machines. The company's labelers are widely used for labeling beer and soft drink bottles and alcoholic beverages. The food, chemical, cosmetic, and pharmaceutical industries are also major users of Meyer equipment.

Other Specialized Equipment and Machinery

Printing machinery and equipment are produced by a number of Massachusetts companies. Photon, Inc. in Wilmington makes photocomposing machines. Whitin Machine Works in Whitinsville builds offset printing presses. Thomson National Press Company in Franklin makes presses for die-cutting, embossing, and roll leaf stamping which are used in the manufacture of corrugated and solid fiber containers, greeting cards, puzzles, and book covers. Specialty Automatic Machine Corp. of Burlington manufactures flexographic printing presses and paper converting machinery including pattern coaters, hot melt applicators, and other specialized equipment. In Newton, Wild & Stevens, Inc. produce composition and rubber rolls for the printing industry.

A new product has been brought to Massachusetts industry by Stacy Machine Company, Inc. of Agawam, which will celebrate its 100th anniversary in 1966. Long a leading builder of special machinery, Stacy now builds the world-famous line of Kidder Flexographic Printing Presses. In 1962, Stacy was purchased by Moore Corporation, Ltd. of Toronto, Canada, the world's largest producer of business forms. As a part of the Machinery Division of Moore, Stacy now builds the complete line of Kidder Flexographic Printing Presses, slitters, and related equipment for shipment throughout the United States, Canada, and other countries. This

The concentration of textile mills in Massachusetts inspired the growth of nearby equipment manufacturers. Spinning frames shown here being assembled are shipped all over the world.

type of printing press is primarily used in the flexible packaging industry. Due to the rapid-drying fluid inks, these presses are particularly adaptable to printing on polyethylene and cellophane as well as foils, paper, and card stock. Stacy Machine Company, Inc. has been an outstanding producer of missile parts as well as precision work for many New England industries. Special machinery has been produced for moulded paper products, stator coil winding, shell loading, cold heading, grinding wheel manufacture and testing, glass forming, food processing, envelope manufacturing, and complete machine tools.

Mathewson Machine Works Inc. in Quincy is a leading producer of automatic machinery for the manufacture of mattresses. Its machines are used by most of the mattress manufacturers in this country and throughout the world. The company also makes slow speed outboard propulsion units for barges and other similar craft. The largest of these engines develops 1,200 horsepower and weighs more than 10 tons.

Artisan Industries Inc. in Waltham and Process Engineering Inc. in Methuen are two Massachusetts firms which manufacture processing equipment for the chemical industry. C. G. Sargent's Sons Corporation in Westford makes conveyor type driers used in processing rubber, tobacco, food, chemicals, and textiles. Other Bay State companies produce specialized machinery and equipment for the woodworking, tanning, and electronics industries.

An important segment of the machinery industry is that which makes pumps, air and gas compressors, and pumping equipment. Warren Pumps Inc. employs more than 300 persons at its plant in the town of Warren. It manufactures three types of pumps: centrifugal, reciprocating, and rotary including screw and gear. Pumps made by the Warren firm are used aboard United States Navy and merchant vessels, in the paper, petroleum and chemical industries, in power plants, and in water works installations.

New York Air Brake Company's Kinney Vacuum Division in Boston is the world's leading manufacturer of mechanical vacuum pumps, which are used throughout the aerospace, electrical and electronics, machinery, chemicals, metals, and food processing industries, as well as in laboratories, universities, and hospitals. Kinney Vacuum manufactures a complete line of mechanical vacuum pumps, mechanical vacuum booster pumping systems, diffusion pumps, evaporators, high vacuum pumping systems, vacuum gauges, vacuum valves, accessories and supplies. Eastern Industries Division of Laboratory for Electronics Inc., with a plant in Newton, is a major producer of small hydraulic pumps and fluid motors for industrial and aircraft applications.

Worthington Corporation's Construction Equipment Division in Holyoke manufactures compressed air paving breakers, rock drills, and tampers. The company makes both portable and stationary compressors. Its compressors are used for railroad and factory maintenance and by small businesses such as filling stations and laundries.

Sturtevant Mill Company of Boston, established in 1883, produces grinding, crushing, pulverizing, and separating equipment machinery. Their air separating machinery goes all over the world, principally to the cement industry for selecting the final sizes of material that make up the end product.

The state has two major producers of measuring and dispensing pumps. In West Springfield, the Gilbert & Barker Manufacturing Company, a subsidiary of the Standard Oil Company of New Jersey, makes gasoline pumps, service station equipment, and oil heating equipment. In Waltham, the W. H. Nichols Company is the world's largest manufacturer of spinning pumps for the man-made fibers industry; its other products include aircraft lubricating pumps and specialized, highly precise milling machines.

Massachusetts is also well represented in another large segment of the machinery industry. This segment specializes in the manufacture of mechanical power transmission equipment. In this group are companies making gears and sprockets, power transmission chain, clutches, transmissions, and bearings.

Boston Gear Works, Division of the Murray Company of Texas, Inc., in Quincy is the world's largest manufacturer of standardized gears and related power transmission products. Among such products are included gears, speed reducers, and sprockets.

Among the other larger manufacturers of gears in the state are Perkins Machine and Gear Company, West Springfield, which will be celebrating its 50th anniversary in 1966, Union Gear and Sprocket Corporation, Quincy, Grant Gear Works Inc., Boston, and Worcester Gear Works Inc., Worcester.

Arch Gear Works, Inc. in Quincy manufactures precision differentials, gear assemblies, precision and commercial gears, and electromechanical devices. Geartronics Corporation in North Billerica specializes in electromechanical devices including precision gear trains, multiratio gearmotors and speed reducers. Their subsidiary, Nashoba Engi-

neering Corporation, makes stripping and taping machines for the wire and cable industry.

The Acme Chain Corporation in Holyoke, a company which started less than 20 years ago with six employees, now has a payroll of over 450. This firm makes roller chain, sprockets, and a variety of chain used on conveyors. Its power transmission products are sold across the country and exported internationally.

Rex Chainbelt Inc., Roller Chain Division, operates two large plants in Massachusetts, devoted to the manufacture of power transmission products: roller chain, sprockets, and flexible couplings. One plant is located in Springfield, the other in Worcester, with a total employment of over 900 people in the two plants. Products are sold and distributed world wide. Also in Worcester is Lundquist Tool & Manufacturing Inc., which produces ball bearings.

In the materials handling field, Lewis-Shepard Company in Watertown is one of the nation's largest manufacturers of electric industrial fork lift trucks. These trucks are used in thousands of plants and warehouses for moving and high storing all kinds of material and merchandise. Electric trucks to handle heavy 20,000-pound stamping dies and automated trucks to handle photographic film in total darkness are typical of the special equipment produced by its design engineers. In addition to its wide variety of electric trucks, Lewis-Shepard also manufactures many types of manually operated handling equipment such as hoisters, stackers, hand lift trucks, floor trucks, and industrial trailers.

United Service Equipment Company, which makes food carts and service trucks for hospitals and hotels, in its Jarvis & Jarvis Division plant in Palmer produces wheels and casters for institutional and industrial trucks and equipment.

Several Massachusetts companies make elevators and conveying equipment. F. S. Payne Company in Cambridge is the largest elevator builder in the state and J. C. Corrigan Co. in Boston is the largest in the conveying field making turnkey systems.

Adding to the variety of machines built in Massachusetts are office machines made by a number of companies. Elliott Business Machines, which recently moved its manufacturing operations from Cambridge to a new plant in Randolph, makes addressing machines and systems. Tecnifax Corporation in Holyoke makes diazo reproduction equipment, papers, cloths, and films for engineering drawing duplication, office copying and systems, training and education, microfilm documentation, aerial reconnaissance photography, and the graphic arts. In Everett, Standard Duplicating Machines Corporation produces standard fluid process duplicating machines and supplies as well as envelope sealing machines.

The Wright Line Division of Barry-Wright Corporation in Worcester makes office equipment for the handling, storing and filing of punch cards, magnetic tape, and memory discs used in connection with automatic data processing. At its Barry Controls Division plant in Watertown Barry-Wright specializes in products for controlling vibration, shock, and noise. It builds systems to isolate vibration from industrial machinery and to cushion shock in such delicate operations as those involved in the space missile program.

Included in the list of Massachusetts-built machines are such diverse items as cranes, hoists, ditch diggers, snow plows, salt spreaders, water demineralization equipment, marine deck machinery, milking machines, cranberry machinery, laundry and dry-cleaning equipment, fish-scaling machines, and restaurant equipment.

Located within the borders of the state are more than 200 machine shops which supply manufacturers with a variety of metal parts and perform an important function in keeping the wheels of industry turning by doing all sorts of repair work on factory machinery.

Machinery for the Electrical Industry

From the earliest days of the electrical industry Massachusetts has been in the forefront in the development of machinery for the generation, transmission, and utilization of electric power.

It was in the Massachusetts town of Great Barrington that in the spring of 1886 occurred one of the most significant events in the history of the electrical industry, a triumph for the youthful inventor William Stanley. Only a few years previous the use of electricity had been largely confined to street lighting and the lighting of factories with cumbersome arc lights. Thomas Edison's invention of the incandescent lamp in 1879 had paved the way for the introduction of electricity into the home, but the low voltage current used for incandescent lighting could be transmitted only a relatively short distance from the generating station.

George Westinghouse, founder of the Westinghouse Electric Corporation, believed that alternating current, instead of the direct current commonly used, if employed with transformers could solve the transmission problem. He purchased the American rights to two transformers patented abroad and en-

gaged young Stanley to experiment with them. Stanley made improvements on the foreign designs and produced the first commercially practical transformer.

Great Barrington became the proving ground for Stanley's experiments. The young inventor set up a laboratory in an abandoned rubber factory and installed a local lighting system in the town using alternating current and his improved transformers. Stanley's transmission system was given its initial test on March 6, 1886. The system worked perfectly and this demonstration set the pattern for the future long-distance transmission of current which made possible the rapid growth of the electrical industry.

In his Great Barrington project Stanley used transformers to step up the current from 500 volts to 3,000 volts for transmission from the generating plant in his laboratory to the town. He then employed other transformers to cut it back to 500 volts for lighting purposes. It is interesting to note that in recent years the General Electric Company at Pittsfield has been conducting experiments with extra high voltage transmission of electric current at 700,000 volts.

Stanley, incidentally, figures in the history of the General Electric plant in Pittsfield. After completing his experiments for Westinghouse the inventor established his own company in Pittsfield and for a number of years manufactured transformers and other electrical equipment there. The Stanley Electric Manufacturing Company was purchased by General Electric Company in 1903.

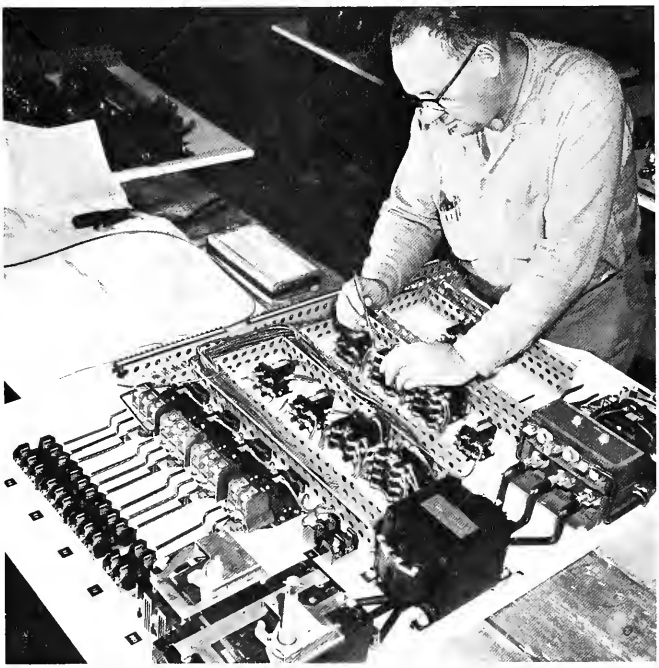
Pittsfield is one of several Massachusetts communities where General Electric Company conducts extensive manufacturing operations. The company is not only the leading producer of electrical equipment in the state, but it is also the state's largest manufacturing employer, with a total Massachusetts payroll of about 30,000.

General Electric's largest Bay State operations are in Lynn. At its big River Works plant there, the company manufactures turbine generators for the production of electric power, engines for military aircraft, marine turbines, and propulsion gears. At other GE plants in Lynn, industrial and aircraft instruments are produced. In nearby Everett the company has a plant making component parts for its Large Jet Engine Department in Evandale, Ohio.

Electric clocks, electric toothbrushes, and electric shoe polishers are made at the General Electric plant in Ashland. At Fitchburg another GE plant produces auxiliary generators for ships and small turbines for industrial use.

The Pittsfield plant of General Electric makes transformers for electric power plants, transformers for power distribution systems, and lightning arrestors. It has a Chemical Materials Department producing phenolics compounds and an Ordnance Department making guidance and fire control systems for Polaris missiles.

There are smaller General Electric manufacturing plants in Chelsea and Lowell. The former makes industrial paints and lacquers. The latter makes insulated wire and cable.



Automatic controls govern much of the operation of today's machines requiring complicated electrical installations.

Stanley's practical solution of the problem of transmission led to the formation, in 1899, of the Condit Electric Company for the production of power circuit breakers necessary for the switching and protection of the electrical circuits. Circuit breakers are the safety devices used on high voltage lines to close and open the circuits, preventing damage under adverse conditions of overloading. Thus, they perform on a large scale much the same function as fuses in a household electrical system. In 1931, the original company was purchased by the Allis-Chalmers Manufacturing Company, a well-known name in power equipment. The development and manufacture of this specialized product continues at the Boston Works of the Allis-Chalmers Manufacturing Company for use throughout the world.

Coppus Engineering Corp., Worcester, produces steam turbines, blowers, air filters, industrial gas burners and sentry valves.

Westinghouse Electric Company has two large plants in Massachusetts. The company's Boston plant is a leading producer of fans and blowers used in ventilation systems. The fans and blowers which keep the air clean in the Sumner and Callahan Tunnels under Boston Harbor were made at this plant. Other products of the Boston plant include heating and cooling coils, electrostatic air cleaning equipment, dehumidifiers, and industrial heating units.

At Springfield the Westinghouse company makes household appliances, including fans, vacuum cleaners, room heaters, food mixers, floor polishers, and hot plates. The Springfield plant also manufactures vending machines for soft drinks and candy.

Sylvania Electric Products Inc., besides its extensive operations in the electronics field in Massachusetts, has several Bay State plants producing electric lighting equipment. The company's plant in Danvers is the world's largest fluorescent lamp factory. In Salem there are three Sylvania plants, one making incandescent lamps, and another turning out iodine-quartz, projection and electroluminescent lamps. The latter is a relatively new type of lighting which makes possible panels of light of any size for such purposes as illuminating ceilings, walls, tables, automobile dashboards and clocks. The third plant specializes in the production of automation chassis for high-speed production items. At Ipswich, the company has still another plant which produces circuit breakers, ballasts, magnetic components, airport and other outdoor lighting, Sun Guns, and miniature lamps.

Consolidated Electric Lamp Company, with headquarters in Lynn, has three Massachusetts plants. Its Champion Lamp Works Division in Lynn is a leading producer of incandescent bulbs and fluorescent tubes. A subsidiary in Danvers, Vulcan Electric Company, manufactures electric heaters, thermostats, melting equipment, and soldering irons. This equipment enables customers to purchase both heaters and thermostats from one manufacturer or in an assembly. Applications for these products include aerospace, medical equipment, atomic submarines, packaging machines, and photographic equipment. Another subsidiary in Lowell, the Heinze Electric Company, makes small electric motors used in such appliances as can openers, mixers, and blenders. The Heinze plant also makes small fans and blowers used in automobiles, house trailers, and watercraft. It produces, too, a line of heat guns and heat torches.

Smithcraft Corporation in Chelsea and the Artcraft Fixtures Division of Special Products Company of Tennessee in Fall River are large producers of lighting fixtures.

Another Boston electrical manufacturer, the Holtzer Cabot Corporation, makes electric motors, gear reducers, and telephone power generating, converting and interrupting equipment. This company, founded in 1875, produced some of the first telephone equipment, including the transmitting and receiving devices used by Alexander Graham Bell.

Culver-Stearns Mfg. Co. Inc., Worcester, produces electrical assemblies, specializing in automotive and marine switches.

S. H. Couch Co. Inc., North Quincy, established 1894, manufactures private telephone systems, fire alarm systems and hospital signaling equipment. Their subsidiary, Couch Ordnance, Inc. of Mattapan, produces switches and relays for missiles.

Chase Shawmut Company in Newburyport is a large producer of electrical fuses, ranging in size from those used in household electrical systems to those used in big power stations.

Hotwatt Corporation in Danvers manufactures heating elements used in electric toasters, coffee-makers, curling irons, and soldering irons. It also makes heaters used in packaging machinery, embossing machines, and plastic extrusion machinery. Astronaut Ed White in his historic walk in space carried a Hotwatt heating device to insure proper functioning of his emergency oxygen supply equipment.

Astro Dynamics Inc. in Burlington has pioneered in the development of brushless D.C. motors, which play a significant role in the

space program. The company is also a leader in the manufacture of heat sinks, used to cool semiconductors in electronic apparatus such as hi-fi amplifiers.

One of the larger electrical manufacturers in the state is the Standard Electric Time Company in Springfield. This firm makes electric clock and fire alarm systems for schools, hospital signalling systems, and electric timers.

In Clinton is the big plant of the Ray-O-Vac Division of Electric Storage Battery Company. This plant makes all of the flashlights and electric lanterns sold under the well-established Ray-O-Vac trade name. In addition, it makes hearing aid batteries, transistor batteries, and battery chargers.

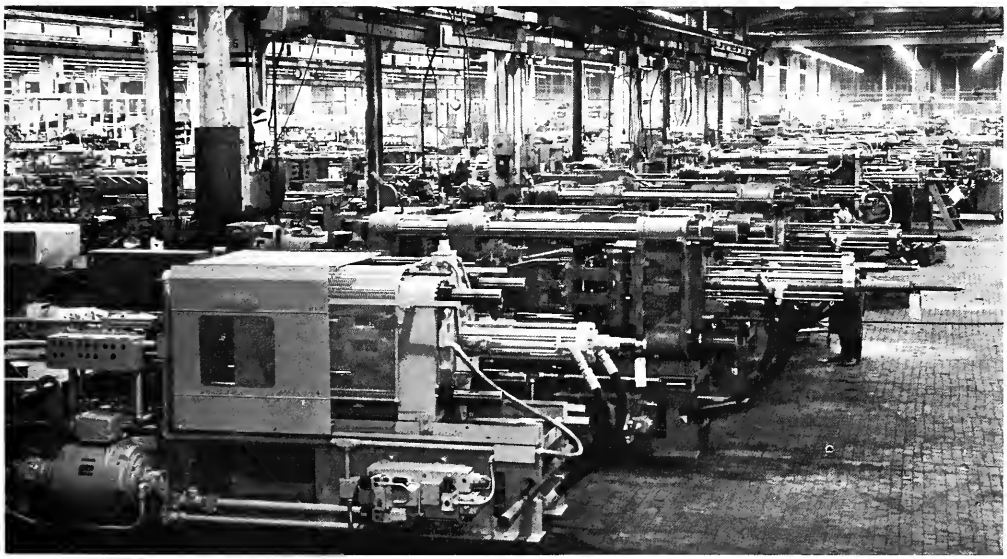
A Massachusetts company which has carved a niche for itself in the market for household appliances is the Signal Manufacturing Company in Salem. This concern, which employs about 800 persons at its plant in the old Naumkeag Steam Cotton mill, manufactures vacuum cleaners, electric floor polishers, hair dryers, can openers, and blenders.

Scattered about the state are scores of other manufacturers contributing to the huge output of electrical goods produced in the Bay State annually. Their products include motors, transformers, switches, switchboards, plugs, sockets, lighting fixtures, storage batteries, junction boxes, heaters, welding equipment, and a host of others.

In the electrical machinery industry, as in the nonelectrical machinery industry, Massachusetts manufacturers have constantly improved their products and have created new machines to meet the needs of an ever-changing economy. Their own two hands, native intelligence, and abundant natural resources were all that the Bay Colonists had to depend on to build for themselves an economically comfortable existence. They had grave need for everything: textiles, leather, building materials, paper, and agricultural equipment.

The urgency of the need for textiles prompted the early development of spinning mills that, in turn, required new and faster machinery for spinning and weaving. These textile machine shops were excellent training grounds for machinists who would later apply their skills to producing hundreds of machine tools for other industries.

Growing generations spread their knowledge from one end of the state to the other, specializing in new and improved tools as the pace of production grew faster. The changes from water power to steam and then to electricity brought new challenges and new answers. Today, old skills support new ones as we move through the Machine Age.



Many hundreds of parts must be produced with absolute accuracy so that final machine assembly can be completed without problems.

The Stone, Clay, and Glass Industry

From the earth — a vital industry

Many old deeds in Massachusetts convey property for an agreed purchase price but reserve the mineral rights. Visions of sugar plums—gold or other precious metals—dance through the head of a purchaser as he reads this clause, and he instinctively reacts to anyone having such a lien on his land. In most cases, however, it refers to gravel or stone, materials difficult to come by in areas where there is a heavy overburden of clay.

True, iron was once mined in both the extreme western and eastern portions of the Bay State. However, this was of low grade and never of much commercial value. On the other hand, granite, limestone, sand, and the abundant clay are still much in use. Clay, which once supported hundreds of brickyards in the state, was the foundation on which the Norton Company of Worcester established the largest abrasive products-making firm in the world. It is named for descendants of Captain John Norton of Bennington, Vermont, where was established in the last years of the eighteenth century a pottery whose products are highly regarded in today's antique business. Although china and pottery authorities contend that china, because of its lurid decoration, had a "high emetic quality," they have nothing but good to report of the classic simplicity of design and color of old Bennington ware.

In addition to concentrating the manufacture of brick in a few plants, evolution has also closed down a majority of the Massachusetts quarries where granite was once obtained. However, since the end of World War II, this trend has been reversed. Granite deposits having characteristics suitable for exploitation by modern production methods have been reopened to help fill the demand for granite products brought about by a high level of construction activity. Although the use of structural granite has largely given away to reinforced concrete in the foundations of buildings and bridges, the granite industry has been able to develop new markets for its products, not the least of which is the protection of concrete structures against attack by harmful salts and acids commonly found in both air and water.

Another important mineral asset is an abundance of good quality non-metallic rock. In an age when huge quantities of concrete are required for paving highways and for building construction, these rock deposits are invaluable. Crushed stone from more than a dozen quarries operating in the state provides the aggregate which is necessary for asphaltic paving as well as for concrete made with Portland cement. The sand of Massachusetts is now used by scores of manufacturers of concrete. The poured variety as well as the precast form is used.

The mining of products from the earth provides employment for nearly 11,000 Massachusetts workers, with about half engaged in that section of the industry which produces abrasive products.

Abrasives marched a great distance from that period in time when our grandfathers were forced to turn the crank of an ancient grindstone while their fathers sharpened the family ax or scythe. Those grindstones, made of sandstone which was cut from strata in natural deposits, did not come into practical use until someone invented a saw with which to cut a flat, circular wheel. Cranking by hand was later replaced by a treadle; and water, dripped onto the surface by a pendant can with a tiny hole in its bottom, was used as a lubricant.

According to the Smithsonian Institution, the familiar grinding wheel of natural sandstone which removes metal by eating and tearing off small particles from the surface has been used to sharpen edged tools for more than one thousand years. Development of the grinder as a machine tool began about 1800. The transition from the old idea of grinding as a wearing-away action to the present concept of grinding as a cutting process was conceived during the last quarter of the 19th century.

From the crude beginnings involving grindstones, the use of abrasives and abrasive products multiplied a thousandfold. Ordinary airplane metals are too soft to stand the tremendous heat of the space age. Far harder metals found practicable to use are so hard that castings made from these metals cannot be cut with the ordinary cutting tools such as a lathe or shaper. Grinding wheels are the answer, specially designed and constructed for the particular job assigned. A grinding wheel is composed of sharp abrasive particles held together by ceramic, resin, or

rubber bonding compounds. The abrasive grits range from aluminum oxide or silicon carbide, both man-made in electric furnaces, to natural or man-made diamonds. Grinding wheels made in Massachusetts are used in industry the world over.

The small town of Chester in western Massachusetts is regarded as the birthplace of the abrasives industry in this country. Discovery of deposits of emery in the town led to establishment of a thriving business in mining this valuable abrasive material. Companies were formed to produce grinding stones and other abrasive products in Chester and nearby communities, using the native mineral.

Although the mining of emery in Chester has long since ceased, and man-made abrasives and corundum from far-off South Africa have replaced the native ore, the abrasives industry continues to flourish in the area in and around Chester. In Chester itself, the Cortland Grinding Wheels Corporation makes grinding wheels and other abrasive products, and the Hamilton Corundum Company produces emery grains and powders. The Hamilton Company is a subsidiary of the American Abrasive Company in nearby Westfield. This firm is an important supplier of grinding powders to the optical and electronic industries.

Other abrasive companies in the area include the Vitrified Wheel Company in Westfield and the Hampden Grinding Wheel Company in Springfield. Blanchard Machine Company in Cambridge is

Automated electrically-heated tunnel kiln for firing grinding wheels.

also a manufacturer of grinding wheels.

Largest of the abrasive firms is the Norton Company, whose principal plant and headquarters are in Worcester. This firm, whose roots are tied to the colonial Bennington pottery, was originally founded by men whose descendants are still key figures in management. First known as the Norton Emery Wheel Company when it was incorporated in 1885, it now has twenty-four plants in thirteen countries throughout the world. Interestingly enough, John Jeppson II, executive vice president of the company, is a grandson of the Swedish immigrant by the same name, the man most responsible for the development of the grinding wheel.

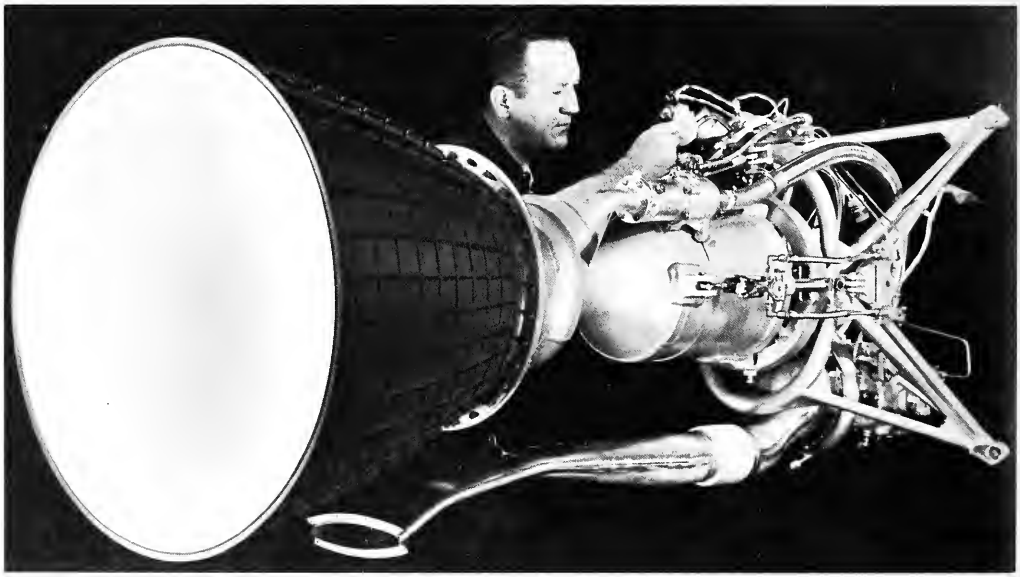
Frank Norton of the Bennington clan was the key figure in the founding of the pottery in Worcester, but one of the four early immigrants from the Swedish village of Hoganas, Swen Pulson, was the man largely responsible for the emery wheel. All four of the immigrants were potters, and Norton Company executives persuaded them to come to Worcester to work at the local pottery. They were the forerunners of today's large Swedish population in the industrial city. Another potter who came over soon after the others was John Jeppson, brother-in-law of Pulson.

Early grinding wheels were made of wood and had a tire of leather to which bits of emery were stuck with glue. Others were bonded with rubber, cement, or shellac. All were very fragile and quite undependable, in comparison to today's requirements and standards. In 1872, in Detroit, Gilbert Hart made a silicate wheel. One of these wheels found its way to the pottery where Pulson determined he could make a better wheel with clay base. And he did.

Emery has a history dating back to the time of the Pharaohs. A natural mixture, in rock form, of impure corundum and magnetite, still unknown in Pulson's time, emery came from Greece and Turkey until Herman Lucas, a Chester physician and amateur geologist, discovered a deposit in a hill of his home town. Yale University scientists confirmed his findings and a company was formed to mine it. This mining company was later taken over by Norton.

Pulson mixed emery with slip clay, the type used in glazing pottery, to make a solid wheel and baked this to hardness in a kiln. He sold these wheels from his home. Jeppson later carried on this work for Norton and at one time not only made and baked the wheels but sold them.

During these early days, Milton Prince Higgins, who had recently graduated from Dartmouth, was



Satellite or missile surfaces exposed to severe temperature gradients or abrasive atmospheric friction can be protected by aluminum oxide or zirconium oxide special coatings as shown in the white area inside the exit cone of this Aegena liquid rocket engine.

named by Ichabod Washburn, of the firm of Washburn & Moen Manufacturing Company, as superintendent of shops at the newly formed Worcester Polytechnic Institute. Washburn had been instrumental in the Institute's founding as a school to provide trained mechanics for industry.

Higgins not only loomed large in the early history of the Institute but in Worcester industry as well. It was he who obtained the financial life blood for the Norton Emery Wheel Company when it was incorporated in 1885 and whose descendants have long headed the Norton Company.

The growth of the company since 1885 has been little short of phenomenal. It entered into all fields of machine shop work and eventually made its own grinding machines.

Other major product lines or activities include high-temperature refractories, pressure-sensitive tapes, high vacuum equipment, tantalum metal production, and masonry and concrete sawing equipment.

The company employs 15,000 throughout the world, with 5,000 of these employees in executive offices and the principal plant in Worcester. This plant is the headquarters for three of its major divisions: abrasives, refractories, and machine tools. Another major division, Behr-Manning, located in Troy, New York, manufactures a complete line of coated abrasives and pressure-sensitive tapes. Other United States manufacturing operations are carried on in plants in New Hampshire, California, and Alabama, including a bauxite mine in Arkansas. Norton also operates international subsidiaries in thirteen countries in Europe, the United Kingdom, Australia, Canada, Mexico, South America, and the Republic of South Africa. Headquarters of National Research Corporation, a Norton subsidiary, are in Cambridge, with other plants in Newton, and Newton Highlands, Columbus, Ohio, and Palo Alto, California. The newest subsidiary of Norton Company is Clipper Manufacturing Company of Kansas City, Missouri. The diversified product line of Clipper includes such items as masonry and concrete saws and blades, core drills and bits, concrete gunning equipment and pumps, as well as concrete conveyors and placers.

Another large company in the abrasive industry in Massachusetts is the Bay State Abrasive Products Company in Westboro. This plant was founded in 1922 by Orello S. Buckner, Leonard M. Krull, and George H. Bullard, who left the employment of Norton in nearby Worcester to start up grinding wheel manufacturing operations in a vacated power house in Westboro. Mr. Bullard left the young company in 1927. Mr. Buckner, a ceramic engineering graduate of the University of Illinois, held the manufacturing reins while Mr. Krull, a graduate of Worcester Polytechnic Institute, doubled in sales and financial responsibilities. In 1936, the two original founders were joined by another Norton man, Earl C. Hughes. It was this triumvirate that nurtured the offspring to third-place stature in today's grinding wheel industry. Bay State is still one of the industry's fastest growing members.

Today Bay State's Westboro plant, offices, and research facilities encompass more than half a million square feet and employ nearly a thousand people. In addition, the company has branch offices and warehouses in Chicago, Cleveland, Detroit, Pittsburgh, Houston, and Los Angeles. In Torrance, California, a Bay State wholly-owned subsidiary, Felker Manufacturing Company, manufactures metal bonded diamond wheels and masonry and concrete sawing equipment for the construction industry. In addition, Bay State has subsidiaries in Brantford, Ontario, Canada, and in Steinsel, Luxembourg, both manufacturing a full line of bonded abrasive products.

Much of Bay State's progress has come from product innovations. These first came from the fertile mind of Ceramic Engineer Buckner. Bay State was the first with reinforced grinding wheels of the raised-hub disc design, as a basic tool for today's welding and metal fabricating industries. Mr. Buckner's interest in research led early to a vigorous and expanding Research & Development activity at Bay State. A recent product of this activity is Bay State's new Copperdyne bond for diamond wheels and for electrolytic grinding wheels. The use of pure copper in Bay State's Copperdyne bond formulations has demonstrated significant advances in carbide grinding efficiency and promises extraordi-

Precast concrete units for building construction has had a rapid growth in recent years.

nary solutions to some of the aerospace industry's stickiest metalworking problems.

Early in 1965, Bay State announced that it would become a division of the Avco Corporation, one of the country's leading diversified industries with extensive space-age research and development facilities in Massachusetts at Wilmington, Lowell, Lawrence, Haverhill, and Everett.

George H. Bullard Company, Inc., Westboro, has been producing specialty grinding wheels since 1927, and in nearby Shrewsbury the Worcester Division of Omark Industries, Inc. manufactures diamond wheels.

Abrasive Products, Inc. of South Braintree is another of the leading producers of coated abrasives and employs approximately 250 in the manufacture of abrasive papers and cloths sold world-wide for both consumer and industrial applications.

American Sandpaper Company in Rockland manufactures the Clipper brand of coated abrasives. Its products, made with abrasives of aluminum oxide, silicon carbide, and garnet, are distributed nationally and widely used in many industries. The coatings are applied to paper, cloth, and fiber.

One of the oldest makers of grinding wheels is Waltham Grinding Wheel Company, Inc. This concern represents a merger of two long-established Massachusetts firms: Waltham Grinding Wheel Company, established in 1880, and Vitrified Wheel Company of Westfield, founded in 1865.

The manufacture of buffing and polishing wheels is aligned with the manufacture of abrasives because abrasive powders are commonly used in the buffing process. One man in the industry described the relationship as "a sort of stepchild to abrasives." Among the Massachusetts makers of buffing wheels are Beacon Supply Company of Chelsea and F. L. & J. C. Codman Company of Rockland.

Limestone is the product mined in Berkshire County, the only area in the state where it is found in quantity. The limestone is found in the Taconic Range of the Berkshire Hills. At the northern end of the range, in the town of Adams, are the lime and limestone operations of Chas. Pfizer & Co. Inc. and the limestone plant of the Georgia Marble Company. Due south in the town of Cheshire is the Farnams plant of the United States Gypsum Company. Farther south in the range is the Lee Lime Company. Together these plants employ more than 300 people and quarry more than 500,000 tons of limestone yearly. Much of this limestone is calcined in kilns, yielding lime equal to half the tonnage of the rock burned. Part of the stone quarried is used in agriculture. Fine ground limestone finds myriad uses as a filler in various types of paint, asphalt, and vinyl floor tile, etc. Lime is the basic alkali of industry, being used in such processes as paper-making, tanning, water purification, and waste disposal, to mention a few. Total value of the mined limestone and its products is about $12.5 million annually.

Limestone has been quarried in the Berkshires for well over a century, and town annals tell of early lime burners making coffin-like shelters of logs to protect them at night from the wolves.

United States Gypsum Company's Boston plant is the only gypsum-product producer in Massachusetts. This plant, which employs approximately 150 people, manufactures a complete line of Sheetrock gypsum wallboard, plaster, and plaster bases. These products are used primarily by the building industry and are marketed throughout the country.

Raw materials for the Boston plant are supplied by ocean-going ships from company-owned mines in Nova Scotia.

Mica, often called isinglass, is another mineral processed in Massachusetts. Huse Liberty Mica Company in Peabody supplies electronics manufacturers with mica insulators for radio and television tubes. The insulators are pieces of the natural mineral reduced to uniform thickness and stamped out in the exact pattern required by the design of the particular tube being manufactured. The mica is imported from India, Africa, and South America.

Industrious Bay Colonists, recognizing the value of the clay deposits they found along the coast, first established a brick-kiln in 1629 at Salem. By 1657 the city of Boston included so many houses of brick, tile, and slate that a traveler recorded it as "presageth some sumptuous city."

At one time there were some 125 companies in Massachusetts making bricks. Today the number can be counted on one hand. Competition from modern plants in other states has thinned the ranks of Bay State brick makers.

The largest of the surviving long-established Massachusetts brick manufacturers is the Stiles & Hart Brick Company, which with modernized equipment continues to produce sand molded face brick in its plant at Bridgewater.

Brick production in the Bay State recently took a spurt as a result of the opening of a new million-dollar plant of the Kelsey-Ferguson Brick Company in Middleboro. The plant, covering 155,000 feet of floor space, has the most modern equipment and is described as "completely automated." The

company has a vast deposit of clay near the new plant.

There are some thirty companies in Massachusetts producing concrete block, which is widely used for foundations of homes and for walls of industrial and public buildings. Some of these companies also make concrete brick and patio blocks.

Several Bay State concerns make concrete pipe. Largest employer in this field is New England Concrete Pipe Corporation of Newton, which makes concrete pipe in a variety of sizes ranging from 6 inches to 10 feet in diameter. Highway construction projects provide the biggest market for the pipe, which is used for culverts and other drainage purposes. On the North Shore, Hume Pipe of New England, Inc. also produces concrete pipes.

New England Concrete Pipe's subsidiary, Northeast Concrete Products, Inc., prefabricates prestressed concrete columns, beams, and sections of walls and ceilings for building construction. It supplied the prestressed concrete for the huge 15-acre Brown & Sharpe Manufacturing Company plant in North Kingston, Rhode Island, which, when it opened on May 18, 1964, was the largest single-story prestressed concrete building in the world. Eastern Schokcrete Corporation in Worcester, employing about 150, uses a process developed in Holland to produce precast concrete units for building construction. In its Worcester plant the firm made structural columns, sills, and pipe shafts for recently-erected buildings on the campuses of several New England colleges, including the University of New Hampshire, University of Maine, Harvard, Brandeis, and Worcester Tech. At the same plant it also produced precast concrete wall panels for the new Prudential Tower in Boston, and at its New Jersey plant the firm made other precast units for the Boston skyscraper.

Use of prestressed concrete in building construction has had a rapid growth in recent years.

A company which is a leader in this field is the San Vel Corporation of Littleton. This firm was already an important producer of ready-mixed concrete when it started fabricating pre-stressed concrete building components a few years ago. The company reversed the usual order of things by installing its pre-stressing production facilities before it built its plant. As soon as production facilities had been installed in the open they were used to manufacture the components for the building erected to house them. The company's $5 million plant is one of few in the industry that is fully enclosed. In this plant the firm fabricated components for the new 14-story William James Hall at Harvard and there it has produced such impressive structural members as 120-foot-long beams, weighing about 60 tons, for the new Lowell Technological Institute auditorium. The company has 350 employees.

Massachusetts concrete manufacturers make various other products. There are at least a dozen firms specializing in concrete burial vaults. There are some twenty companies which prepare ready-mixed concrete for construction purposes.

The mix for a grinding wheel is measured into the mold accurately and spread carefully to achieve uniformity.

While Massachusetts' mineral wealth is limited, it does have valuable deposits of granite. Granite quarries, principally in the eastern part of the state, supply stone for highway and building construction and for cemetery memorials. There are several firms in Quincy which specialize in memorials, and H. E. Fletcher Company in Westford is a leading producer of granite for construction purposes.

This company, whose big quarry in Westford has yielded more than 50,000,000 cubic feet of granite in the 85 years the company has been operating, is a major producer of granite curb for highway construction. From this quarry and other quarries which the company owns or has available to it, the firm also supplies a variety of types of granite for architectural use.

The Fletcher Company has been a pioneer in the development of improved methods of quarrying. The task of freeing blocks of stone from the ledge has been made easier by the use of a device which employs a controlled high energy flame to cut narrow channels into the ledge. Once freed, the blocks of granite are neatly sliced with wire saws, which, with the aid of abrasives, cut through the stone in a manner somewhat comparable to the slicing of butter with a wire frame.

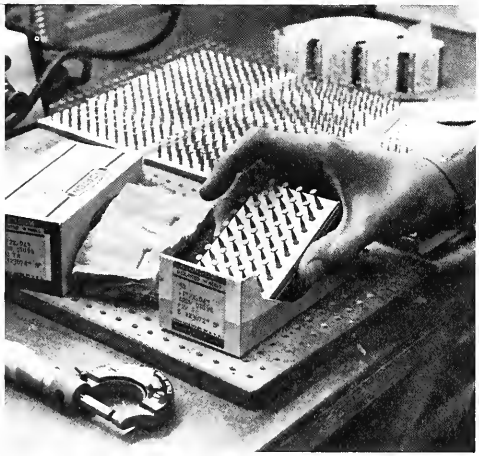
The Westford firm has developed several by-products which utilize the small pieces of granite which are sheered off in the process of preparing the stone for construction purposes. Granite chips are sold as a roofing material. Pulverized granite is sold to poultrymen to provide the grit which poultry must have to aid in the digestion of food. In East Longmeadow, the quarrying of red sandstone for building construction use is being revived by the McCormick-Longmeadow Stone Co.

A catastrophic fire at sea played a part in the establishment of the Johns-Manville Products Corporation plant in Billerica. The burning of the S.S. *Morro Castle* in 1934 hastened research work by Johns-Manville which resulted in the development of a fireproof material for ship bulkheads made from asbestos and diatomite (the fossilized remains of microscopic marine plants recovered from areas once submerged beneath the sea).

All walls, partitions, and ceilings in the S.S. *United States* and many other American-built ships are constructed from this material, which is produced exclusively at the Billerica plant. The fireproof paneling designed for marine use is also used extensively in industry as an insulating material. A. W. Chesterton Company in Everett specializes in mechanical packings for industrial machinery such as pumps, compressors, and molding presses.

There are several small Bay State companies which manufacture asbestos brake linings for cars and trucks.

Stylon Corporation, with two plants in Massachusetts, is an important producer of ceramic tile, widely used for bathrooms and kitchens of homes and for corridors of schools and other public buildings. The company, which is the only ceramic tile manufacturer in Massachusetts, makes wall tile at its main plant in Milford and floor tile at its plant in nearby Northbridge.



Continuing research in abrasive use has developed more than 200,000 types of grinding wheels.

Data processing cards automatically control precise weighing of abrasive combinations for grinding wheels.

It also has plants in Alabama, California, and Utah.

Ceramic tile is a burned clay product. It is made either glazed or unglazed in a variety of attractive colors and patterns. The tiles pass continuously through kilns at temperatures up to 2,300 degrees Fahrenheit. The trip through the kilns takes 15 to 40 hours, depending on the type of tile.

Kilburn Glass Industries in Chartley, originally in the business of making glass parts for manufacturers of costume jewelry, is now primarily a supplier to the electronics industry. It makes parts of glass bonded to metal which are used in electronic semi-conductors such as transistors and diodes. Among the company's other products are lenses for projection systems and indicator lights for electrical appliances such as stoves and coffee-makers. Hermetite Corporation in Avon is another leading producer of glass-to-metal products.

Some of the most admired stained glass windows in American cathedrals were designed and produced by Boston firms. Boston stained glass studios are not the largest in the country, but they yield honors to nobody in the quality of their work.

Charles J. Connick Associates, the largest stained glass firm in New England, has produced windows for churches and public buildings all over the United States and abroad.

The late Dr. Connick, founder of the firm, was a native of Pennsylvania. His interest in colored glass was aroused by a chance meeting with the proprietor of an opalescent art glass shop in Pittsburgh. For three years he worked there learning the craft and studying the art of the European designers who created stained glass windows in famous cathedrals. His knowledge and skill so impressed the great architect, Ralph Adams Cram, that Cram gave him his first major commission, which was to produce a window for one of his finest structures, All Saints Church, Brookline. In 1910 he established the firm which bears his name. Of the many windows created by Connick, perhaps the best known are the great Rose window and others in the Cathedral of Saint John the Divine in New York, the windows of the Heinz Memorial Chapel at the University of Pittsburgh, and Grace Cathedral, San Francisco.

Another long-established Boston stained glass firm is that of Wilbur Herbert Burnham. Burnham, still active in the business with his son, Wilbur H. Burnham, Jr., designed and executed impressive windows in both the Cathedral of Saint John the Divine in New York and the National Cathedral of Saints Peter and Paul in Washington, D.C.

The American abrasives industry has grown from an experimenting potter stubbornly working with clay bonding for abrasive wheels to the development of an industry meeting the needs of the machine age. Today, refractories, born out of this abrasive development, place the industry on the doorstep of the space age.

Although small in numbers, both in terms of numbers of companies and in total employment, the stone, clay, and glass products industry has made many significant contributions to the state's economy. This industry provides an annual Massachusetts payroll of $70,819,000 and produces material with a value added equal to $147,894,000 each year.

Artist develops stained glass panel to be used in the window of the Daniel L. Marsh Chapel at Boston University.

The Ordnance Industry

From flintlocks to missiles—maintaining our national security

In the John Woodman Higgins Armory, a private museum in Worcester established by John Woodman Higgins in 1928 to house a collection depicting 3,000 years of metal craftsmanship, there is a set of armor with a bullet hole in the top left segment. This bullet hole serves as mute testimony of the end of the age of chivalry. Knights in armor, as warriors, ceased to exist at about that time, signaling the end of man's effort to defend himself with iron clothing.

This was a significant event in the evolution of arms, but more significant advances have occurred in Massachusetts in the past 170 years. These years saw ordnance advance from the muzzle loading flintlock musket of Colonial days (which used a piece of flint in the hammer for striking a spark to set off a powder charge which fired the bullet) to today's missile. Now, more than ever before in history, man knows there is no shelter capable of protecting him against the weapons of war. His only defense is ordnance, missile against enemy as well as missile against missile.

American troops in the Revolution carried a motley collection of arms, all flintlocks and mostly guns with a smoothbore barrel. Many of these weapons were provided by the French. Blacksmiths and machinists in the colonies turned their hand to gunsmithing, and made weapons of various specifications prepared by the state Committees of Safety. In Massachusetts the committee ordered a musket with a barrel three feet nine inches long which would take a one-ounce ball or shot. To fire this rifle, the Revolutionary soldier had to pour powder into the muzzle of the barrel, add the heavy bullet, ram home paper or cloth wadding, and then prime the firing pan which detonated the charge from a spark struck by the flint. Truly, every shot counted in those days. The only saving grace was that the British Brown Bess, the cumbersome Tower musket carried by the Redcoats, required just as much time to load. The exception to these types of arms were the Kentucky and Pennsylvania rifles whose barrels were rifled for accuracy and distance.

In 1795, some years after the Revolutionary War, the United States Government established an armory at Springfield; but, in its first year of operation, it produced only 245 muskets. Production increased to major proportions after the start of the Civil War in 1861. An early attack by the troops of the Confederate Army destroyed another United States arsenal at Harpers Ferry, Virginia, thus placing the entire burden of arms production for the Union forces onto the armory at Springfield. Output jumped from 14,000 in 1861 to 277,000 in 1864. This was not enough, however, and contracts were made with many small gunsmiths, twenty-five of them in Massachusetts. These gunsmiths came through in an amazing fashion. Like the earlier Revolutionary arms, the Civil War musket was still a muzzle-loader; but it was rifled, and fired a conical bullet of somewhat smaller calibre. The flintlock firing method had been superseded by the percussion cap.

It is said that some Army officials during the war adamantly refused to convert from a single shot rifle to the magazine or multi-shot rifle on the theory that a soldier would waste too much ammunition. However, the need for more fire power brought forth scores of ideas for a repeating type weapon. One inventor was Christopher M. Spencer, a native of Connecticut, who had patented a repeater with a seven-shot magazine. Refused by Army generals, he finally went to President Lincoln and, through his intercession, obtained an order for his firm, the Spencer Repeating Rifle Company, of Boston. It had limited use as a cavalry weapon and after the war, Spencer, lacking finances, was unable to continue and went out of business.

After the Civil War, the armory at Springfield continued to manufacture an improved weapon. This became known as the Springfield. It converted the earlier weapons issued during the war to breech loaders, which were known as the "trap door" models. The armory made Krag-Jorgensen repeaters for the Spanish-American War and from this gun developed the repeating Springfield rifle used in World War I. An armory engineer, John C. Garand, invented the famed M–1 of World War II. This weapon was also largely produced at the Springfield armory and in the factories of several other companies.

Massachusetts, just as it took a leading part in providing arms for

wars, has devoted its tremendous research and technical production to man's latest weapons of offense and defense. Use of electronic devices for detection and tracking of hostile weapons and for guidance of retaliatory weapons has placed the Bay State's electronic industry in the forefront of the country's defense preparations. At the same time, other Massachusetts industries, producing ordnance items ranging from small fuses to giant turbines and propulsion gears for our largest warships, are making their contributions to our national security.

Raytheon Company, headquartered in Lexington and with eighteen plants and laboratories in Massachusetts, and Sylvania Electronic Products, Inc. in Waltham, a subsidiary of General Telephone & Electronics Corporation, are big producers of missile systems and subsystems. In 1950, a Raytheon system guided an experimental Lark missile to history's first destruction of an aircraft in flight by a guided missile. Ten years later the Raytheon-developed and produced Hawk missile was the first to intercept another missile. The Raytheon Company is the only electronics company with prime contracts for two operational weapons systems, the Hawk and the Sparrow III. Sparrow III is an air-to-air missile whereas the Hawk is a ground-to-air missile.

Raytheon is also developing giant radars for the Nike-X intercontinental ballistic missile defense program. This company developed and produced the tracking radar which enables the Navy to pinpoint the position of enemy planes and helps direct Tartar missiles to destroy them. Other Raytheon accomplishments include production of the electronics package of the compact guidance system inside the Polaris A-3 missile—a unit small enough to fit in a file cabinet drawer; development of electronic controls to help make it possible for the Army's vehicle-carried Mauler missile to be fired while the vehicle is on the run; development of a "built-in" sonar system to enable United States submarines to locate enemy submarines or surface ships at greatly increased distances; and production of an "over the horizon" radar. Revelation of this latest penetration device beyond the lines of sight was made by President Johnson in 1964.

Sylvania has a prime contract with the United States Air Force to produce ground electronic command and control systems for 1,500 Minuteman missiles and 15 underground launch centers in North Dakota. This missile, with a range of more than 6,300 miles and a speed of more than 15,000 miles an hour, is the mainstay of the nation's deterrent force of intercontinental ballistic missiles. This system will provide remote control for testing, readying, and launching the Minuteman. Under two other prime contracts from the Air Force, Sylvania laid 1,000 miles of hardened cable in deep trenches in North Dakota and is producing electronic security systems to help guard unmanned Minuteman silos.

Infrared heat environmental test for the Hawk missile.

Automated wire wrap equipment provides reliability required for complicated electronic packages in Polaris fire control systems.

From its Waltham plant, Sylvania has delivered electronic equipment to Vandenberg Air Force Base in California. This equipment serves to monitor missile readiness and to control unmanned Minuteman installations. Other Sylvania-Waltham developments include an experimental advance radar system for the Nike-X anti-missile system, a magnetic tape device which sharply reduces the number of technicians required to prepare instructions for the Army's digital computers, and equipment for the data processing phase of the Ballistic Missile Early Warning System.

In the early 1950's, when the intercontinental ballistic missile was being investigated as a weapon system by the Air Force, the major problem was to design and develop a payload vehicle (carrying a nuclear warhead) which could be boosted into space, then survive the pressures of re-entry into the earth's atmosphere to reach and destroy an enemy target. Playing a major role in helping the Air Force solve this re-entry problem has been Avco Corporation through two Massachusetts divisions: the Avco-Everett Research Laboratory (AERL) in Everett and the Research and Advanced Development Division (Avco/RAD) in Wilmington.

The feasibility of developing such a re-entry vehicle was proven by AERL through the pioneering use of shock tubes, in which gas under high pressure is "fired" past a fixed miniature vehicle shape to simulate the aerodynamic characteristics of re-entry. Avco/RAD was organized in 1955 to actually undertake the development of re-entry vehicles. The first of these were called "heat sink" designs, because the heat of re-entry was absorbed by heavy metal "sinks" on the blunt end of the vehicle. Later vehicles were the more streamlined and efficient shapes made possible by the use of ablative heat shields, where the ablative material chars slowly and vaporizes away during re-entry, helping to dissipate the heat of atmospheric re-entry.

The Mark 4 re-entry vehicle, developed by Avco/RAD, was used on the Atlas and Titan missiles, America's first ICBM weapon systems. The Division's Mark 5 and Mark 11 have been developed for Minuteman, the solid-fueled missile which is now the backbone of the nation's deterrent military strength.

A tiny instrument that would fit handily into the palm of one's hand has the job of telling a giant missile "where to head in." The instrument is a gyroscope, and many thousands of them have been built by the Norwood-based Precision Products Department of Northrop Nortronics for more than

The Navy's MK 44 torpedo, designed by a Massachusetts company, is equipped with an acoustic-homing device which searches out the target and guides it in for the kill.

twenty different missile types now in the armory of U.S. weapons. Such familiar missiles as Polaris, Minuteman, and the Tartar-Terrier shipboard missiles fly with Nortronics' gyros.

General Electric Company is doing important defense work at several plants in Massachusetts.

In 1941, the General Electric Company brought together personnel and resources in Pittsfield to meet the then urgent World War II requirements of the military. Since that time, the many ordnance programs successfully completed at this Pittsfield facility have earned for the Massachusetts plant a major place among the small group of U.S. manufacturers capable of designing, developing and manufacturing precision and ultraprecision electromechanical ordnance equipment of various sizes and complexities for a broad range of military applications.

During World War II, the Pittsfield facility achieved an outstanding record in the design and production of torpedoes and mines for the U.S. Navy. This close relationship with the Navy has continued to the present. It has led to such projects as the design and development of the Mk 44 torpedo, presently the Navy's most advanced operational anti-submarine torpedo (and the only operational torpedo that can be used for air-drop, ASROC and surface launch). The G.E. Ordnance Department was the original industrial producer of seawater batteries for torpedo propulsion in the United States. Much advanced work, including the development of test equipment, has been done in Pittsfield on the study of boundary layer control techniques in an effort to find ways of reducing the effects of drag on torpedoes and other underwater bodies.

The G.E. Pittsfield plant is also a leading supplier of weapon control systems for the Navy. Most notable has been the design and development of fire control systems used aboard Polaris FBM submarines. The computerized G.E. system continuously co-ordinates movement and changing location of the Polaris submarine with target information for each missile—up to the moment of launch. From beneath the sea, the system calls the signals to launch 16 Polaris missiles at a rapid one-per-minute rate.

Also noteworthy among the fire control equipment with which the Pittsfield facility is associated are the Mk 37 gun director developed for the Navy during World War II; the Mk 56 gun fire control system which the Navy put in operation during the Korean war and which now is being adapted for use in landing helicopters and light aircraft aboard ships; and the Mk 73 gun and guided missile director used with Tartar missiles, the most accurate two-axis shipboard director in use by the Navy today.

The versatile inertial guidance systems used to guide Polaris missiles launched from moving submarines beneath the ocean's surface to targets as far as 2500 miles away are also manufactured in Pittsfield. These relatively small and lightweight yet highly accurate and reliable systems are produced by G.E. from designs developed by the Massachusetts Institute of Technology Instrumentation Laboratory.

G.E. also designed, developed and manufactured at Pittsfield the missile handling system now in use aboard Navy vessels carrying the Talos missiles. Through a complex of mechanisms and controls, this intricate system automatically selects designated missiles from the ship's hold and transfers them to the missile launchers above decks. Weighing 50 tons, it is the largest single piece of ordnance equipment ever manufactured at the Pittsfield plant.

At the General Electric facilities in Lynn, where the development of America's first turbojet engine began in 1941, the Small Aircraft Engine Department is manufacturing more than 1,000 small gas turbines annually. Production includes the J85 engine for military trainers and fighters, as well as for the XV-5A, a jet capable of vertical takeoffs and landings. Also in production in Lynn is the T58 turboshaft engine, which powers helicopters for all branches of the armed forces, the T64, which has helicopter turboprop and vertical takeoff applications, and the CF700 and CJ610 engines for both military and civil applications.

General Electric in Lynn also builds turbines and propulsion gears for some of the Navy's largest surface vessels and nuclear-powered submarines. The Lynn plants also produce instruments for many famous military planes, and fuel cells to serve as power sources for spacecraft. At the G.E. plant in Everett, many vital engine component parts are made for assembly at the company's Large Jet Engine Department in Evendale, Ohio. General Electric employees at Fitchburg also build small turbines to provide shipboard power for some of the Navy's most modern ships.

In the Northwestern corner of Massachusetts at North Adams is the headquarters of the Sprague Electric Company, the nation's largest producer of passive electronic components, such as capacitors (condensers), resistors, etc. Sprague Electric also is an important source for microcircuits and transistors. The company's four plants in North Adams employ some 4,500 to make it the largest

employer in Northern Berkshire County. An additional 4,500 workers are employed at 22 other plants in the United States, including one in Worcester, and in foreign countries. Sprague Electric pioneered the concept of high-reliability electronic components and is the acknowledged leader in this difficult field of military electronics. During World War II, it won five Army-Navy "E" Awards for excellent production performance. Sprague capacitors supplied the energy to detonate the first atomic bombs and were instrumental in the success of the Navy VT Fuse Program during World War II.

Texas Instruments Incorporated, Attleboro, fabricates and assembles precision-engineered sub-assemblies on a contract basis for various federal government ordnance programs. Circuit breakers are also manufactured for ordnance vehicles.

Massachusetts has been known for more than a century for the small arms which it manufactures: revolvers, sporting rifles, and shotguns. A leader in this field is Smith & Wesson of Springfield, makers of revolvers since 1852, whose contribution in World War II reached the incredible total of 1,311,000 revolvers representing 80% of all Allied Forces requirements. Today this firm is the leading manufacturer of police weapons and handcuffs in the country. Its modern plant is the most unique in Massachusetts, for it has underground areas where manufacturing could be continued in the event of war.

Testing a production technique to increase reliability and decrease size and weight for Polaris advanced guidance system.

In Westfield, Savage Arms, now a division of Emhart Corporation, has one of the world's largest plants devoted to the production of sporting rifles and shotguns. Predecessor of Savage was the J. Stevens Arms Company, located in Chicopee Falls from its founding in 1864 until, merged with Savage, it moved to the present modern plant in 1960. Savage and Stevens were major sources of military weapons during World War II, their production of rifles, submachine guns, machine guns, and other ordnance items totaling many millions of pieces.

Iver Johnson Arms & Cycle Works in Fitchburg makes revolvers and shotguns, and Noble Manufacturing Company in Williamsburg also produces a line of sporting arms.

Harrington & Richardson, Inc., with plants in Worcester and Gardner, manufactures revolvers, shotguns, and rifles. The company has been an important producer on military weapons and, during World War I, made shoulder type flare guns. During World War II, this company made .22 calibre training rifles, .45 calibre rifles, and submachine guns, known as Reising guns, for American Marines. They were named for Eugene G. Reising, the designer, who was affiliated with the Harrington & Richardson firm. The company also made line throwing guns, handcuffs, and leg irons for the Navy and Coast Guard. During the Korean conflict, Harrington & Richardson produced more than 400,000 M-1 Garand rifles and, in 1963, completed contracts for more than a half a million M-14 automatic military rifles.

The Westinghouse Electric Corporation plant in Springfield has at times handled large ordnance orders. During World War II, it made gyro stabilizers for the Navy and also produced the amazingly accurate Bullpup air-to-ground missile. This was devised to reduce heavy losses from ground fire shot at low-flying United States planes in the Korean War. In tests, this missile has been fired from a plane two miles away at a target only 10 inches square and it scored a bullseye.

Flare-Northern Division of Atlantic Research Corporation, whose Massachusetts plant is located in West Hanover, has the facilities for developing and producing explosives and pyrotechnic devices. Flare-Northern Division is the result of the acquisition and merger by Atlantic Research Corporation of the former National Northern Division of National Fireworks Ordnance Corporation in Hanover and the United States Flare Company of Saugus, California.

During World War II, National Fireworks first loaded 20-millimeter and ammunition for the British Navy and later for United States forces. Soon after Pearl Harbor, the company received an order to load incendiary bombs for a mysterious "Destination X." The identity of "Destination X" was revealed later on April 18, 1942, when General James Doolittle's flyers made their famous fire raid on Tokyo.

Flare-Northern makes rocket igniters and small electro-explosive devices which activate the mechanisms which keep missiles on their courses, as well as fuses, primers,

flares, and signals. The company loads artillery shells, produces a wide variety of explosives, and makes devices which activate seat ejectors in military aircraft. Its extensive facilities for research and development include a three-mile test range on a 2,000-acre tract in Halifax, Massachusetts.

Hesse-Eastern Division of Norris-Thermador Corporation makes a variety of ordnance products including fuses and rockets, and has facilities in Everett and Brockton. It designed and developed the whole system for the M-72 rocket grenade, a light anti-tank weapon which can be carried by the individual soldier and fired from the shoulder. At its Brockton plant, it assembles launchers for the M-72. This company also produces artillery shells and fuses for small arms and for artillery.

In New Bedford, the New Bedford Defense Products Division of the Firestone Tire & Rubber Company makes artillery shells. In Brockton, the Magnesium Castings Company makes mortar fuse assemblies.

Kollmorgen Corporation of Northampton and its subsidiary, Inland Motor Corporation, developed the exceptionally accurate star-tracking periscopes for aiming Polaris missiles with which United States nuclear submarines are equipped. Inland torque motors are not only used in the star-tracking periscopes but they are also widely used on various missile weapons.

Just as in the early days of Massachusetts, when blacksmiths and machinists became gunsmiths, so today the state's electronics industry has been of inestimable value to the nation in providing the technical knowledge and the skills in producing ordnance for the space age. Ordnance work in private industry in this state, not including the United States Government installations, the Boston Naval Shipyard, the Springfield Armory, and the Watertown Arsenal, employ approximately 18,500. This total does not actually reflect the full extent of the impact of ordnance on the state's economy, for these official statistics apply only to that portion of defense-based industries whose production is formally classified as ordnance. In addition, there are several thousands of jobs in scores of companies which are more commonly known as defense industries and which produce material and equipment other than ordnance for the national defense.

Minuteman "Nerve Center" controls launching of this powerful intercontinental ballistic missile from fifty feet below ground.

The Electronics Industry

From radar and M.I.T. comes a new tool

The barbed wire is gone, but the chain link fence still stands along the Vassar Street edge of the Massachusetts Institute of Technology in Cambridge. The barracks-like buildings a few feet away housed the Radiation Laboratory during World War II. There, in strictest secrecy, United States and British engineers pooled what they then knew about radar. Out of "The RadLab" came the radar and fire control devices which helped save Britain from Nazi bombers and turn the tide of World War II.

During the last quarter-century, M.I.T. has spawned much of what is today the electronics industry. Graduates of M.I.T. are found in electronic companies throughout the nation, but especially in Massachusetts.

It has become a kind of tradition for adventurous engineers to organize companies to manufacture and market devices that they developed in the laboratory. In the nation's investment community, they find without too much difficulty risk-takers who are glad to share the free-enterprise adventure. Many of the small electronic companies in Massachusetts today, and some of the large, trace their beginnings to a university laboratory.

In fact, the Route 128 industrial complex grew out of the creative environment generated by M.I.T., Harvard, Tufts, and other universities in the Boston-Cambridge area. In this area is one of the most eminent communities of technical scholars in the world. When the Air Force research and development activities at Hanscom Field, Bedford, are added to the university-industrial combination, it becomes abundantly clear why Massachusetts is recognized as one of the world's prime centers of advanced electronics. Close relationship with centers of technical excellence is characteristic of electronics, a $17 billion business. In dollar sales in the United States it is fifth, and it is still growing. In Massachusetts, nearly 68,000 persons are employed by electronic and allied companies, and they produce equipment worth $1.5 billion yearly.

Electronics is the science and technology used to direct and control the conduction of electricity in gas, vacuum, liquid, or solid-state matter. Its devices and systems sense, collect, process, and transmit information; and, they either control machines or present the processed information to human beings for their direct use. The products of the industry fall into four major categories: military and space, industrial and commercial, consumer products such as radios, television and phonographs, and components, which are the parts and accessories used in the other three product categories.

In recent years, the military-space and industrial-commercial parts of the business have been increasing in Massachusetts. The state is still a major supplier of components, but the employment total in this area has decreased. Massachusetts has never been a prime manufacturing center for consumer electronics.

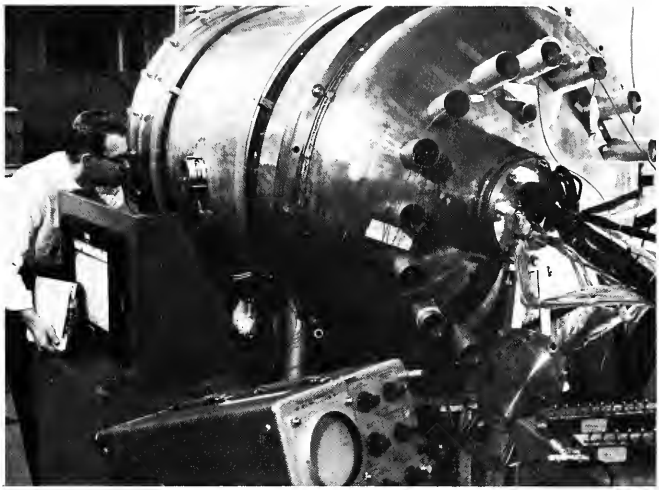
More and more, the opinion is being expressed that electronics is not really a separate industry, but rather a technology and a tool which is useful in many industries. A glance at some of the other chapters in this book will show what is meant by this. In the space industry, in the ordnance industry, in the instruments industry, and others, electronics is an indispensable tool. The work of many Massachusetts companies which could properly be called electronic will be described in chapters dealing with the industry they serve.

The pursuit of advanced electronic techniques by Massachusetts engineers and scientists has created some of the keystones of our national defense. The SAGE system, now in nationwide operation to protect the United States against surprise air attack, was designed at the Lincoln Laboratory of M.I.T. Its network of radar-fed computers keeps track of every cubic foot of air space over and around the country, and is ready to direct the interception of any invading aircraft. M.I.T.'s original computer research on Whirlwind I and Lincoln's extension of this work to provide for SAGE a high-capacity, high-speed data processing system marked the beginning of the computer age.

SAGE (for Semi-Automatic Ground Environment) is the first of the computer-based defense systems. It grew out of the Cape Cod Project, planned and tested in Massachusetts under that code name. Lincoln Laboratory, where SAGE was created, is managed by M.I.T. and supported by the

United States government. It does advanced research in electronics for defense systems and space exploration. It is part of the huge military electronics effort centered at Hanscom Field, Bedford. Lincoln Laboratory also helped design BMEWS (Ballistic Missile Early Warning System), whose giant radar antennas stand guard in the Arctic and in England to prevent a surprise missile attack over the North Pole.

Massachusetts companies produce some of the most important equipment in the nation's defense system. Raytheon Company of Lexington, the largest electronics company in New England, and one of the largest in the world, works on defense and space electronic systems which cover practically all frequencies and wavelengths. These range from sonar for the Navy's anti-submarine warfare program to control and information systems for the Apollo lunar mission. Its products are as small as transistors, and as large as the Hawk missile systems used in Vietnam. It builds radar for air traffic control as well as for Defense Department needs. Raytheon designs and manufactures microwave communication systems which relay telephone and television signals thousands of miles. It is the nation's largest producer of electronic equipment for boating, and has pioneered in the use of microwave energy to cook or heat foods. Thousands of Raytheon Radarange electronic ovens are now in use in restaurants, institutions, and vending installations.



Electronic equipment for an orbiting astronomical observatory must first be tested under extreme thermal-vacuum conditions more stringent than anticipated in outer space.

A "Clean Room" where precision electronic components are manufactured under completely dust and dirt free conditions.

From cooking with radar to missile guidance—it's all electronics.

Sylvania Electric Products Inc is another versatile producer of electronic devices and systems in Massachusetts plants. Sylvania had its beginnings in 1901, when the company's founder purchased a half-interest in a Middleton company producing light bulbs. This company and one from Pennsylvania doing similar work joined forces in 1931 to form Sylvania, now a subsidiary of General Telephone and Electronic Corporation.

Four of Sylvania's nine divisions have their headquarters in Massachusetts: Lighting Products, Salem, Electronic Systems, Waltham, Semiconductor, Woburn, and a newly created division, Commercial Electronics, Bedford. This diversified electronics company is an important producer of electronic flash bulbs and missile control systems, of television tubes and military computers.

The era now unfolding will probably be known as the computer age, rather than the nuclear age or even the space age. The computer is considered by many to be the most important technological development in human history. Its possibilities appear boundless, not just in keeping records, inventories, and payrolls, but in education and medicine, in space exploration, and in the management of human affairs.

Massachusetts has played a key role in the development of the computer. The first automatic digital computer was completed at Harvard University in 1944. It was "retired" in 1959. One-half of the machine is at Harvard, and the other half is on display at the Smithsonian Institution in Washington.

Much of the early work on computer techniques was done at universities, but industry has now taken the lead in advancing the technology and Massachusetts industry is up front.

Honeywell's electronic data processing division, with headquarters in Wellesley Hills and 14 plants in the state, has become one of the world's leading computer manufacturers in the past 10 years. Its rapid growth is indicated by a doubling of its plant space since 1963 to nearly one million square feet, and a doubling of employment to more than 6,500 persons. More than 12 per cent of the 50,000-man total employment of Honeywell Inc. is in the Greater Boston area.

Honeywell computers, marketed through more than 50 sales offices in the United States and 20 overseas offices, are being used for everything from baking cakes and scheduling truck shipments to producing NASA's Saturn moon rockets and providing backup to medical researchers at the National Institutes of Health.

A computer made by Digital Equipment Corporation of Maynard reads and records the information from thousands of photographs taken in nuclear physics experiments at M.I.T. and other research centers. Digital is also known for its pioneering work with TV-like computer displays and its oceanographic and biomedical applications for computers. This company's computers are also used to process business data.

Computer Control Company, Framingham, has applied digital computer technology to a broad range of real-time control and information processing requirements, as diverse as a control system for railroad freight car classification yards and as spacecraft simulators for training Gemini and Apollo astronauts. Special Computer Control Company data automation systems controlled the scientific information gathering aboard the Mariner space probe vehicles to Venus and Mars.

Special-purpose computers are also made by GPS Instrument Co., Newton Upper Falls, Adage Inc., Boston, and George A. Philbrick Researches Inc., Dedham.

Computron, Inc. of Waltham, with a new plant planned in Bedford, produces a magnetic iron-oxide coated tape which is used to store data and calculations electrically in the computer.

Anelex Corp. of Boston is one of the principal manufacturers of high-speed printers and other equipment which gets information into and out of the computer.

At its plant in Sudbury, Raytheon Company is producing a very special computer for the Apollo program. It is making the on-board digital computer and associated ground equipment for both the Apollo command module and for the lunar excursion module (LEM) which will land on the moon. The computer, smaller than a suitcase, is the "brain center" of the Apollo guidance and navigation system. It has hundreds of integrated circuits, which make it small and light. A semiconductor integrated circuit is a small chip of material, usually silicon, which is processed in a special way to do the work of an assemblage of separate devices such as transistors, diodes, capacitors, resistors, etc. It switches energy, amplifies signals, and does all the other things that a much larger group of separate devices can do.

Monolithic integrated circuits comprise a brand new technology which has emerged from the semiconductor industry. In much military and commercial electronic equipment, as well as many radio and television sets, tape recorders and stereo units, transistors and other semiconductors have replaced the vacuum tubes of early radio

days. Integrated circuits will, in the years ahead, be replacing groups of transistors and diodes, so that electronic equipment can become even smaller and simpler.

The semiconductor industry blossomed from intensive work in solid state physics, in which Massachusetts played and still plays an important role. Semiconductors are well named. As carriers of electric current, they are halfway between a conductor and an insulator. They freely conduct electricity under certain conditions, and stop it under other conditions. The way they do this, and the speed at which they do it, are determined by skilled materials processing, circuit engineering, and manufacturing techniques.

All electronic equipment uses a variety of components to conduct the signal, or delay it, or switch it, or filter out some frequencies and let others through. These parts and accessories of circuits are developed and produced in scores of large and small Massachusetts plants. In fact, this state is one of the two or three primary centers for manufacture of electronic components.

Transitron Electronic Corporation of Wakefield, Sylvania Semiconductor Division in Woburn, ITT Semiconductors in Lawrence, and Sprague Electric Company of North Adams and Worcester are the largest among semiconductor manufacturers in the Bay State. Transitron, Sylvania, Sprague, and ITT Semiconductors also have important programs going for the development and marketing of integrated circuits. Sprague is also the world's largest producer of capacitors, an electronic component that stores electrical energy in a circuit briefly for a timed discharge.

Aerovox Corporation of New Bedford is a major producer of capacitors, as is The Cornell-Dubilier Electronics Division of Federal Pacific Electric Co., also in New Bedford.

Sigma Instruments Inc. of Braintree specializes in highly sensitive relays and other components which control circuits. These components have been used in everything from space probes aimed at Venus to such commercial and industrial applications as automatic elevator instrumentation and a variety of applications in computers.

Many electronic systems which measure temperature variations use thermistors, devices whose resistance to electric current changes to a precisely known degree of change in temperature. Fenwal Electronics of Framingham is a major producer of thermistors. Fenwal Incorporated of Ashland, manufacturers of commercial and industrial temperature controls, produces a product line of thermistor sensing temperature controllers.

In Chicopee, the F. W. Sickle Division of General Instrument Corp. manufactures a variety of electronic components, including television tuners, which allow you to switch a knob and tune any channel in or out.

The Gamewell Company of Newton, known throughout the world for its police and fire signal alarms, also manufactures potentiometers, a circuit component which measures electrical quantities. Gamewell's most recently developed alarm systems employ electronic techniques, replacing the electromechanical circuits in the early systems. There are several smaller companies also producing various types of potentiometers.

Ace Electronics Associates Inc. of Somerville is one of the most unusual component manufacturers in the nation. In this company, which also makes potentiometers, nearly 90 per cent of the employees are handicapped physically, mentally, or emotionally. It is a policy of the company to hire as many handicapped persons as possible. They are paid at the same wage rates as employees in similar plants, and they have chalked up an outstanding record for safety.

Electronic equipment uses hundreds of other parts and accessories which are not called components but are vital for performance and reliability. Massachusetts companies have an outstanding, industry-wide reputation for quality workmanship in this field. ITT

The "backboard" of computer system contains a maze of wires, some of which are connected manually while others may be attached with automatic equipment.

Cannon Electric's Salem Division produces plugs and connectors for an astounding variety of applications in radio, TV, and all kinds of electronic equipment.

Cambridge Thermionic Corporation in Cambridge makes a broad line of electronic "hardware," from coils to special-purpose connectors and plugs. Ucinite Company, Newton, a division of United-Carr Incorporated, makes connectors, switches, and indicator lights.

Although Massachusetts has never concentrated on production of consumer electronic appliances like radios and TV sets, it is the home of several nationally known makers of high quality consumer equipment. H. H. Scott, Inc. of Maynard designs and produces high-performance amplifiers, tuners, speakers, and consoles for stereo hi-fi enthusiasts. K.L.H. Research and Development Corp., of Cambridge, has become a pacesetter in the field of solid state stereo components. National Radio Co. Inc. of Melrose is internationally known to many thousands of amateur radio operators for its line of receivers and transmitters, and is one of the oldest manufacturers of communications equipment in the United States. Automatic Radio Manufacturing Company of Boston makes auto, portable, and home radio sets. Symphonic Electric Corporation in Lowell is a leading producer of phonographs, with a line that extends from manually-operated phonographs to the most sophisticated sets.

A highly skilled individual worker completes all wiring and final assembly of lots of 15 or 20 electrical circuits at a time.

Electronics is notorious for abbreviated language, like TIROS for Television and Infrared Observation Satellite. One of the first of these, called acronyms, was RADAR, for Radio Detection and Ranging. It has become an accepted word in the English language.

Many of the companies which got into the radar business after World War II were founded by former workers at the M.I.T. Radiation Laboratory. One such was Laboratory For Electronics, Inc., whose corporate headquarters is in Waltham. The Electronics Division of the company has become an industry leader in systems for the control and navigation of aerospace vehicles. Among other major projects, LFE Electronics designed and built the Doppler radar navigation system used in the F-105 Thunderchief fighter-bomber weapons system.

LFE Tracerlab, a Waltham division of the company, was the first commercial organization in applied radiation, and is now one of the largest. In addition to nuclear instruments and radiation monitors, Tracerlab makes process control equipment, and supplies radioactive chemicals and sources for virtually every radioisotope requirement. LFE also has two divisions in Connecticut and subsidiaries in Belgium and Italy.

Radar has come a long way in the past decade. Its advances were stimulated partly by efforts to develop a defense against the ballistic missile. Because mechanically steerable radar antennas cannot simultaneously detect and track numerous missiles and decoys, millions of dollars are being spent for development of radar systems which, among other things, would require no moving parts.

In the phased arrays which have resulted, the narrow radar beam is electronically steered quickly and accurately, and a computer directs the entire operation. Microwave Associates Inc. of Burlington is a major supplier of electronic elements used in phased array systems. Microwave Development Laboratories Inc. of Needham makes components and subassemblies for radar systems. Bomac Division of Varian Associates in Beverly is a major producer of microwave tubes and other equipment for radar. In fact, eastern Massachusetts shares with two or three other United States locations the distinction of being the key centers for microwave design and production.

Transportable electronics is perhaps the fastest growing segment of the military market today because of the "brushfire wars" which have erupted in various parts of the world. Craig Systems Corporation, Lawrence, a division of LeFebure Inc., specializes in airliftable "huts" or shelters which are crammed with communications equipment and which can be flown quickly to any part of the world. At the Burlington plant of Radio Corporation of America, transportable control towers and other equipment for "instant airports" are designed and manufactured. Parts of the system are now being used by United States tactical forces.

The prototypes of complex airborne and ground-based electronic

systems are planned, designed, developed, constructed, and tested by rapidly growing Sanders Associates, Inc. of Bedford. These systems include tactical radars, guidance and control equipment, fuzing systems, and electro-optical systems.

The mushrooming growth of electronics has spilled over into other engineering areas, particularly optics. One of the fastest growing fields today is electro-optics, and the most exciting new tool in this merged technology is the laser.

The laser (Light Amplification by Stimulated Emission of Radiation) is not yet 10 years old, but applications of this family of devices are enthusiastically being explored in communications, surgery and medicine, weapons, precision metalworking, scientific measurements, and chemical processing.

The special kind of light from a laser is thousands of times more intense than any other known light. This is because the light waves are all about the same wavelength and they are "in step," not scattered like the light waves from a bulb in the middle of a room. The energy is concentrated in a thin pencil-like beam and can be focused by optical methods into a tiny spot of highly concentrated power. To control and use these light waves, engineers adapt techniques developed in harnessing radio and radar waves.

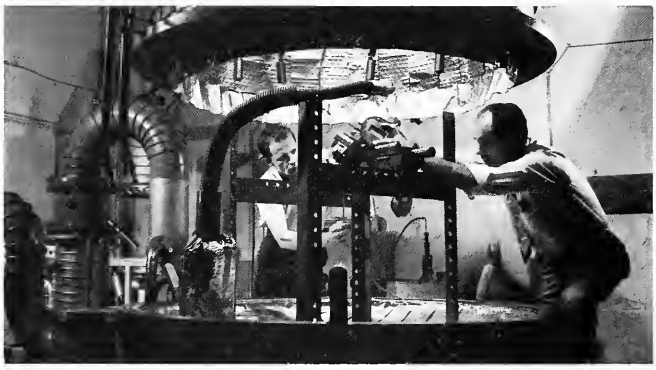
Extensive development and applications work on the laser is going on in Massachusetts industrial companies, universities, and medical research centers. A ruby laser made by Raytheon Company was employed by M.I.T. scientists in the first successful attempt to bounce a laser signal off the moon and detect the reflected energy. At Sylvania Electronic Systems, Waltham, engineers have used a laser beam to transmit television signals. Devices built at Maser Optics Inc., Boston, are being used to explore eye surgery and other medical applications. These companies and others are also applying the exciting new device to metal welding and cutting, optical radar, and communications, among many technical areas.

Laser work has picked up so much speed in the past two years that United States astronauts are now planning a laser communications experiment for the Gemini 7 flight in 1966. Using a small laser made of semiconducting material, the astronauts will exchange light-beam signals with a ground station at White Sands, New Mexico.

Itek Corporation, Lexington, is a leader in the development and production of information systems for government and industry. These systems include aerial photography cameras, automated equipment for analyzing photographic information, memory-centered computers, film printers and offset platemakers for graphic reproduction. Itek equipment is being used in military reconnaissance, space exploration, detection of earthquakes and underground nuclear explosions, crop and natural resource survey, and commercial printing.

In south central Massachusetts, a company which is expert in every phase of the optics art also presents an outstanding example of a wedding of electronics and optics. American Optical Company, Southbridge, is heavily involved in laser work, including the development of the first glass laser, a major advancement in this field. It is also a pioneer in fiber optics or the use of flexible glass "pipes" which transmit light, even around corners, without scattering it. These fibers are being used for a wide variety of applications, many of them in conjunction with electronic instruments. In the medical field, they are used in viewing instruments for direct examination of hard-to-reach parts of the body. For example, such fibers have been used to see into the interior of a living dog's heart and may someday be used in the diagnosis of human heart defects.

The Boston area, a world renowned medical research center, has naturally become an important focal point of medical electronics. The Pacemaker, which electronically stimulates the heart, was developed by a Boston doctor, Paul M. Zoll, in association with Electrodyne Company, Inc. of Westwood.



Giant furnace removes gases and other impurities from microwave tubes.

Medical instrumentation using electronic techniques is produced by many Massachusetts companies.

This state is already one of the few world centers of a relatively new science, radio and radar astronomy. Research groups explore the heavenly bodies by listening to the radio energy they emit under various conditions, or by aiming earth-generated electronic signals at them and studying the reflected energy picked up by extremely sensitive instruments.

The huge, saucer-shaped reflectors, or antennas, stationed atop some of the highest hills in Massachusetts are symbols of the area's pre-eminence in the search for knowledge about the moon, planets, stars, and the undiscovered worlds beyond our Milky Way.

The "dishes," some of them enclosed in protective radomes which look like giant golf balls, can be seen on Haystack Hill in Tyngsboro and Millstone Hill in Westford, the sites of two M.I.T.-Lincoln Laboratory antennas, on Sagamore Hill in Hamilton, and Prospect Hill in Waltham. Highly precise receiving equipment and other devices used with these antennas are made in Massachusetts. Ewen Knight Corp. of Natick is a pioneer manufacturer of the receivers which measure the energy collected by these antennas. TRG, Inc. of East Boston built the electronic equipment which feeds energy into the world's largest radio-radar astronomy reflector, the 1,000-foot-wide "dish" at Arecibo, Puerto Rico. The Arecibo observatory was designed and built under the direction of Air Force Cambridge Research Laboratories in Bedford.

Electronics will be just as important in the exploration of "inner space," the oceans of the world, as it is in outer space. The science of oceanography is now growing rapidly. The Woods Hole Oceanographic Institution of the southern coastline of Cape Cod is one of the principal points of increased activity in this field, and many Massachusetts companies are leaders. Anti-submarine warfare programs are closely tied to the new emphasis on oceanography, and, here too, Bay State laboratories are performing some of the most advanced work in electro-acoustics. Massa Division of Dynamics Corporation of America in Hingham is one of the most important United States producers of underwater detection equipment. Nortronics Division of Northrop Corporation, at its Marine Equipment operation in Needham, has been a major supplier of equipment to the Navy for use on Polaris submarines from the start of the program. This equipment consists, in part, of the Type 11 periscope drive systems, operation consoles; BRA-8 communication systems; and radiometric sextants. Nortronics over the past 15 years has supplied hundreds of items of stabilization equipment for use on almost all types of combatant naval vessels and is still doing so. The importance of this region in advance underwater technology is emphasized by the decision of several non-New England companies to locate their electro-acoustics research laboratories along Route 128, known the world over as "Electronics Highway."

There are a very substantial number of relatively smaller electronics companies scattered about the state but largely concentrated in Eastern Massachusetts. By size, the majority of these companies employ between 50 and 200 and produce a wide variety of products, some as prototypes while others in mass production. The uses of these end products vary greatly since they serve many markets.

Almost without exception, these companies have been established in the post-war era as off-shoots or spin-offs of existing companies. Sometimes the development of a company has been the result of one or more scientists and engineers off to test their laboratory theories in a practical business enterprise.

To merely catalog the long list of these smaller company names would do injustice to the ingenuity of their enterprises and the limitation of this book does not allow otherwise. A word description of some of their principal products does give some hint of the nature of their operations such as magnetic tape, R. F. Coaxial cable and connectors, wave guide and microwave components and tubes, semi-conductors, hearing aids, solid state units, power supply units, cable assemblies, diodes, transistorized power supplies, potentiometers, relays and switches. Together with the very large companies and serviced by a widening complex of supplier manufacturers—these constitute the electronics industry in Massachusetts.

In 1930, electronics pioneer David Sarnoff of Radio Corporation of America foresaw the day when there would be "a theater in every home." Now that television, stereo and hi-fi have made this come true, the predictions of today's dreamers do not seem too outlandish: computer-run homes, remote shopping, accident-proof traffic, pocket television sets, and instant banking, all done by pushing buttons on your home telephone to connect you with a public-utility computer.

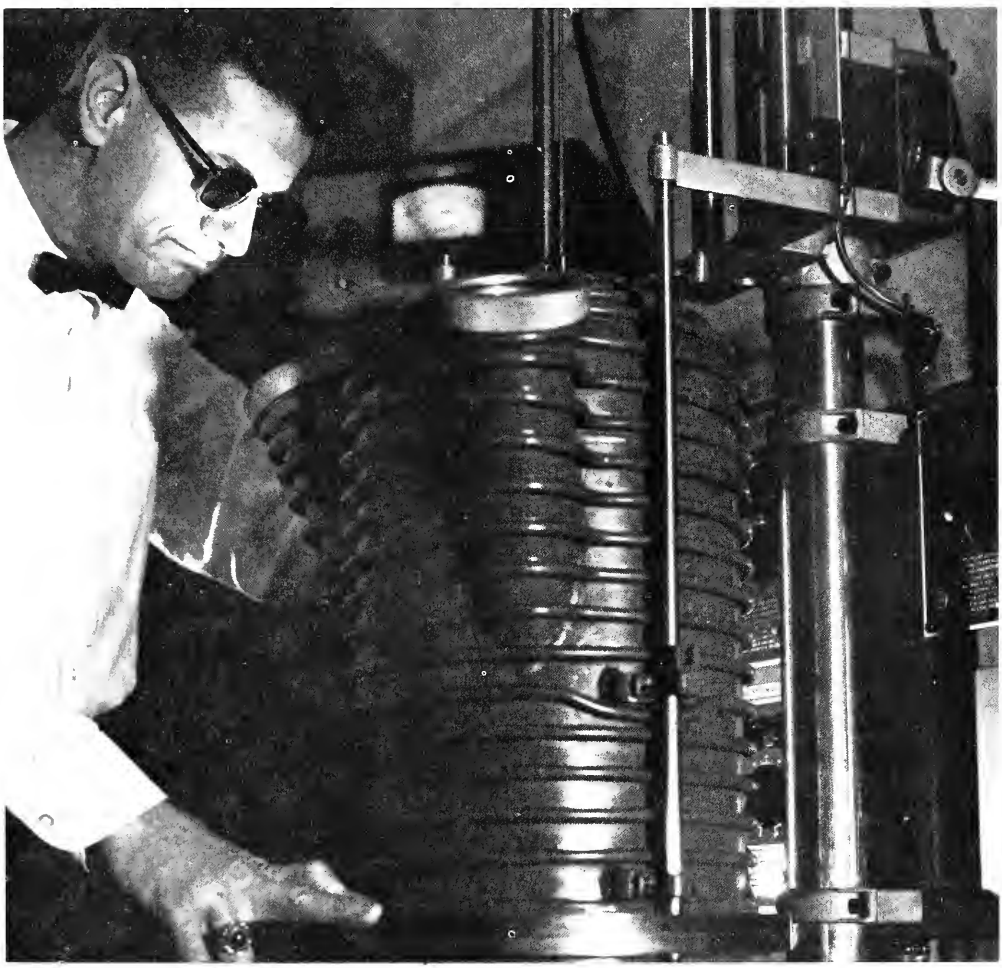
The computer is the hinge upon which the door to the future will swing open. Small computers in the home will plan and control meal preparation, and program cleaning operations. They will record and remind the householder of all social

engagements; they will teach the children; they will calculate and pay the income taxes.

This master computer in the home will control washing machines, dishwashers, refrigerators, air conditioners, lighting, electric stoves, and other household appliances. A combination of a computer and a small, flat TV screen which can hang on a wall will enable the housewife to shop by dialing her favorite store for information about goods and services. She will be able to dial a central library for information about a particular play or novel or musical comedy.

The future promises other electronic marvels including ultra-miniature devices implanted in the body to regulate damaged human organs, laser tools to perform bloodless surgery, and medical diagnoses and treatments prescribed by computers and transmitted to doctors anywhere in the world.

The electronics industry in Massachusetts, born in a climate of technical excellence and nurtured by free enterprise, is even now helping to make these and other electronic wonders as real as today's baseball game on TV.



This newly developed furnace grows crystals of silicon, germanium and other materials used for transistors, diodes and as base material for microminiature circuits.

The Instruments Industry

Producing an amazing array of tools for industry and science

The ordinary electrical current in a home is 115–230 volts. This is adequate power to provide light and run appliances. Imagine a laboratory instrument which creates electrical energy of 10,000,000 volts! Such an instrument is produced by a Massachusetts firm. It is the largest model Van de Graaff accelerator built by High Voltage Engineering Corp. in Burlington. It is used to produce a powerful radiation beam for basic research in exploring the structure of the atomic nucleus.

The accelerator is huge; it is as long as a football field, and no other company in the world makes anything comparable to it. It is one of the principal reasons why America has been able to stay out in front in atomic research.

Van de Graaff accelerators are named for the inventor, Dr. Robert J. Van de Graaff, who built the first multi-million volt electrostatic accelerator at Massachusetts Institute of Technology. Smaller models of the Van de Graaff accelerator are widely used for the treatment of cancer. High Voltage Engineering Corp. came into being in 1946 largely to fill a need for accelerators as medical instruments. Today accelerators built by High Voltage are in use in hospitals in all parts of the Free World.

The achievements in research and technology of this comparatively young firm have added luster to the proud record of Massachusetts companies which for many years have been producing valuable instruments for industry and science.

The term "instrument" means many things to different people. The surveyor associates the term with a transit or a level, the surgeon with a scalpel or forceps, the meteorologist with a barometer or an anemometer. To a lawyer a deed is an instrument used to convey property, and to a musician instruments are played in a band.

In so far as industry regards them, instruments are essentially indicators, measuring devices, and tools that control processes. Instruments can also detect, sense, compare, and analyze. The world of instruments is truly amazing. Many of the instruments used in industrial and medical laboratories are quite intricate and require the specialized skills and training of a person who can correctly interpret their findings. Some instruments are extremely delicate and must be protected against vibration, and housed in special areas free of dust, with temperature and humidity carefully controlled, all these being factors that affect their accuracy.

The manufacture of instruments is one of the nation's fastest growing industries, and it can truly be said that Massachusetts is a prominent state in this area. Compared with shoes and textiles, it is regarded as a young industry, but its roots in Massachusetts go deep. Some of the best known names in the industry are those of Bay State companies which have pioneered in their fields. There are some 200 companies in Massachusetts producing instruments and the number is increasing. Employment in 1963 totaled approximately 28,803 jobs which produces a payroll of $172,000,000 and a value added by manufacture equal to $345,000,000 annually. Five years earlier in 1958 the figure stood at 21,012. In 1953 the total was only 18,116.

The manufacture of instruments in Massachusetts may be divided into four major groups: (1) measuring, recording, indicating, and controlling; (2) scientific instruments; (3) surgical, dental, medical, and diagnostic instruments; and (4) optical instruments.

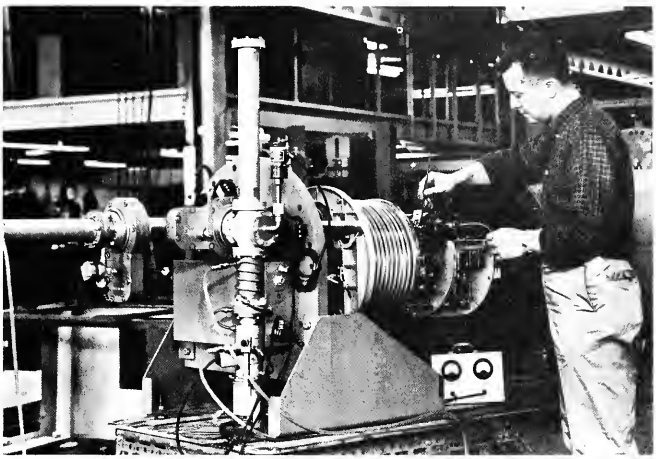
In the manufacture of measuring, recording and controlling instruments and systems, the largest and perhaps best known company is The Foxboro Company, founded in Foxboro in 1908. It now employs over 5,000 people in its Foxboro and East Bridgewater plants alone. The company produces mechanical, pneumatic, and electronic instruments to measure and control practically any variable vital to processing. Among the industries that turn to this Massachusetts firm for the ultimate in automatic control are chemical, petroleum, paper, textile, metals, power, utilities, and food. In recent years, Foxboro has developed digital computing systems and aerospace instrumentation.

Another large producer of instruments in Massachusetts is the Instrument Department of General Electric's Industrial Electronics Division in West Lynn. This G.E. department employs over 2,600 people in the manufacture of indicating instruments, special testing equipment, recording instruments, timing devices, telemetering and process instrumentation systems. It has, as well, a line of component

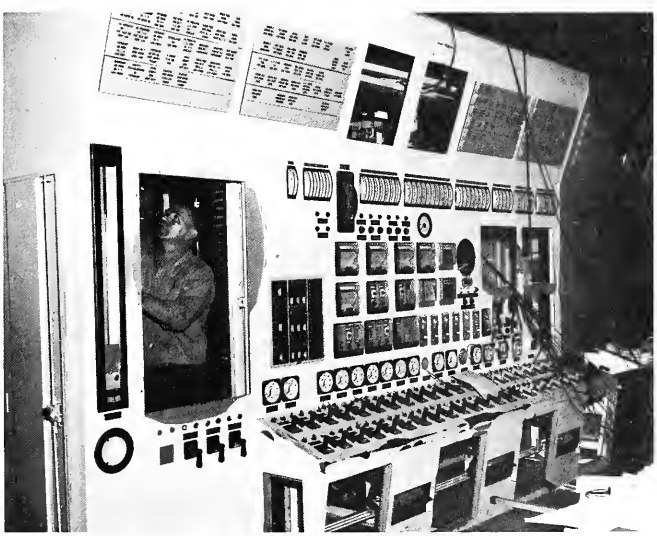
instruments and systems for aerospace application. Aircraft instruments are also produced in large quantities in this division. At its high-voltage laboratory in Pittsfield, General Electric manufactures precision high-voltage electrical bridge networks, instruments measuring lightning surges, and special electronic-type instruments for measuring voltage, current, and watt loss.

General Radio Company of West Concord, the country's oldest electronic instrument manufacturer, produces a diversified line of electronic test instruments and laboratory standards. These are used for test calibration and maintenance by manufacturers and users of electronic equipment, such as radio and television transmitters and receivers, military electronics, satellite trackers, and computers. Other General Radio products are used by industries to measure physical quantities including rotational speed, electrical insulation, resistance, noise, and vibration. The company pioneered the development of many of the products it manufactures.

Two widely-used instruments illustrate the diversity of products made by General Radio. The company's "Strobotac" electronic stroboscope is a source of very short, bright, repetitive flashes of light triggered at accurately known rates by an electronic generator. The flashing light, when used to illuminate a rotating object, can produce the optical illusion of slowing down or stopping the motion. Motion is "stopped" when the flashing rate of the stroboscope and the rotational



Technician makes final adjustments on a 400,000 electron volt Van de Graaff particle accelerator.

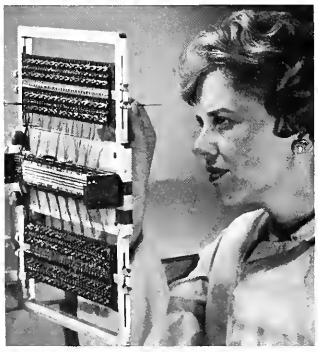


Final assembly of control panel for a nuclear power station.

rate of the object being observed are the same. Since the flashing rate is known and is read from a dial, the stroboscope can be used to measure rotational speed. When the flashing rate differs slightly from the rate of rotation of the object, the motion appears to be slowed and is an exact, slow-motion replica of the high-speed motion of the object.

Another interesting General Radio instrument is the automatic capacitance bridge, which measures the capacitors used in electronic equipment, radio and television receivers, computers, and all types of electronic circuits. These components are measured in a fraction of a second, and the capacitance value is indicated in illuminated numerals. By means of auxiliary equipment, capacitors can be fed in automatically and the output of the device can operate card and tape punches and other data processing equipment, as well as automatic accept-reject devices. Capacitors are produced in astronomical quantities for today's electronic industries, and each unit must be measured. The automatic bridge greatly speeds up this process, which formerly had to be done manually.

General Radio was founded in 1915, and its first catalogue was a 10-page leaflet listing a few relatively simple instruments and some standard electronic components. Its latest catalogue is a 272-page book listing more than 900 items. In the last 10 years the company has placed on the market more than 140 new products, averaging better than one new product a month.



Space-age needleworkers weave a web of hair-fine interconnecting wires on "rope-memory" modules for the Apollo on-board guidance and navigation computer.

The Electronics Division of the Baldwin-Lima-Hamilton Corp. in Waltham employs 600 people in the design and manufacturing of strain gauges and electronic force measuring systems. Crosby Valve & Gage Co. in Wrentham is an established and important producer of pressure-activated gauges and recording instruments used in power and processing plants. Other Massachusetts companies in this category produce special instruments such as those made by H. H. Scott, Inc., in Maynard, to measure sound and noise.

Tracerlab, A Division of Laboratory For Electronics, Inc., Waltham, was the first commercial organization to enter the applied radiation field. It makes a wide variety of nuclear instruments and systems to measure and detect radiation including laboratory, research, and medical instruments; radiation monitoring instruments and systems; and process control equipment such as the beta gauge.

Keleket, also a Division of Laboratory For Electronics, Inc., was the developer and manufacturer of the first commercially successful X-ray generator. Today it is one of the major medical X-ray equipment companies in the United States. It is no exaggeration to speak of Keleket as the inventor for the X-ray industry. Among Keleket firsts: solid state X-ray generator; ceiling mounted tube-crane; flip-flop 90/90 table; grid pulsed image intensifier system; and battery operated mobile.

Trans-Sonics, Inc., Burlington, designs and manufactures measuring and control instruments for temperature, pressure, level, and flow. Their instruments are used in a great variety of applications ranging from the measurement of shaving cream temperature in Boston to atmospheric pressures near the planet Mars.

One of the largest and most widely-known companies manufacturing water meters is the Hersey-Sparling Meter Co., employing 450 people in its Dedham plant. In the exciting new frontier areas of meteorology, oceanography, and space sciences, Alden Electronic and Impulse Recording Equipment Co., Inc. of Westboro has built a base of instant graphic facsimile communications and display equipment, now installed in national and international networks. The company is now bringing its equipment and systems to bear on the "paper work explosion" problems of government, industry, and commerce. A company in Stoughton, Brookfield Engineering Laboratories, confines its product line to viscometers, instruments that measure the degree of fluidity of a liquid.

The United Electric Controls Company in Watertown designs and manufactures a wide line of electrically-operated devices that control temperature, pressure, and vacuum. Its products have a broad range of application. The company's special purpose temperature controls are used to de-ice antennas, to prevent overheating in aircraft fuel systems, and to control the curing of tobacco in barns. Special purpose pressure-vacuum controls automatically regulate heating systems and give warning when leaks or breaks in the line in pressurized telephone cable systems occur.

Metals & Controls Inc., a division of Texas Instruments Incorporated

in Attleboro, employing over 3,000 people, manufactures a broad line of electrical, electronic, thermal, mechanical, and magnetic control devices, including thermal protectors, relays, thermostats, circuit breakers, switches and electronic sensors. Metals & Controls started as General Plate Co. in Attleboro, producing rolled gold plates for the jewelry industry, and in 1921 acquired the Spencer Thermostat Co. of Cambridge. In 1959 it became a division of Texas Instruments.

J. A. Spencer, founder of Spencer Thermostat Co., made an important discovery, the thermostatic bi-metal snap-acting disc. To explain its action, the disc is made up of two dissimilar metals firmly bonded together. When the disc is heated, the metal on one side expands more than the metal on the other side. This process causes the disc to snap in about 1/100,000 of a second. When the disc is cooled, it snaps back to its original concave position by the reverse process. Industrially, the disc principle is used to prevent electric motors from overheating. In the home, disc type thermostats are used to automatically defrost refrigerators and control temperature in clothes dryers. In addition to motors and appliances, disc type controls are used in numerous electronic, aircraft, aerospace, and ordnance applications. In the area of fixed temperature controls, this division of Texas Instruments is the nation's largest producer. In motor protection alone, over 200 million fixed temperature motor protectors are currently in use.

Simplex Time Recorder Co. in Gardner makes time recorders, master clock, fire alarm and automatic monitoring control systems.

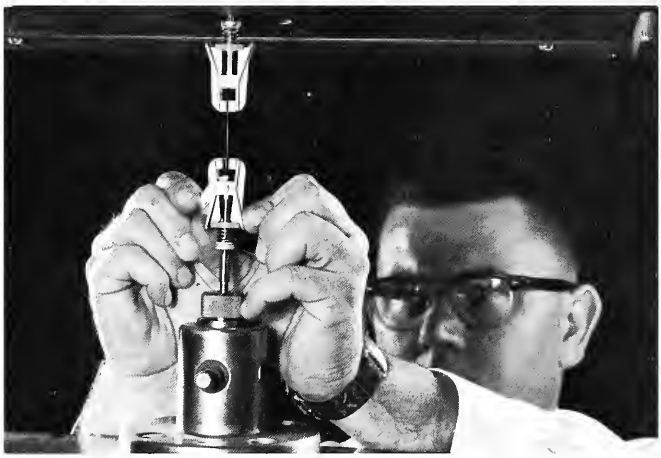
Several Massachusetts companies, while not instrument manufacturers themselves, are important suppliers of parts and components. One such company is J. H. Winn Inc. in Winchester, founded in 1868 as a 2-man business. This company specializes in the manufacture of dial hands and precision assemblies. It is the largest and the oldest company of its kind in the United States.

Weather instruments such as barometers, thermometers, and hygrometers are also made in Massachusetts. In Dorchester, these weather instruments are made under the Swift Instruments, Inc. brand by an affiliated company, Standard Thermometer, Inc.

In the second division of the industry, manufacturers of scientific instruments, are some large companies. One, Edgerton, Germeshausen & Grier, Inc. started as a 3-man partnership in 1934, now has annual sales of $48,850,000 and employs 2,818 people, about half being scientists and engineers. It occupies large plants in Bedford, Boston, and Salem, with branch facilities in Las Vegas, Nevada, Santa Barbara, California, and Albuquerque, New Mexico.

During World War II EG&G conducted much of the developmental testing of nuclear weapons and since 1956 has been the prime contractor for the test instrumentation and control systems and supporting services for Project Rover/NERVA, a program to develop nuclear-powered rocket engines for deep-space missions beyond the moon. EG&G is internationally renowned for its instruments which derive information from ultra-high-speed phenomena involving light, heat, power, radiation, and sound. Among recent accomplishments are optical beacons for geodetic satellites, deep-ocean cameras, and a series of 100-megacycle counting instruments used in huge particle accelerators for study of the atom's nucleus.

Another fairly sizable company in this category is Baird-Atomic, with plants in Cambridge and Waltham. It was organized in 1936 to manufacture spectrochemical instruments. It employs nearly 550 people, and its product line has been expanded to include nuclear, laboratory, electronic and optical instruments, sold all over the world to universities, hospitals, laboratories, and private industries.



Single fiber is prepared for a tensile test on a delicate load-weighing system.

A most unusual instrument developed by the world-famous Arthur D. Little, Inc., industrial research firm in Cambridge, is the ADL-Collins Helium Liquefier, a device which currently supplies a major portion of the free world's supply of liquid helium (liquefaction temperature is −456°F). Liquid helium is used in laboratory testing of materials and for cooling space communications devices such as the maser. The ADL organization now employs more than 1,200 people.

GCA Corporation, formerly Geophysics Corporation of America, with headquarters in Bedford, manufactures and sells instruments, equipment, and systems used in precision measurement, vacuum processing, and photomask production. GCA also performs advanced research, development, and engineering, principally in the aerospace and defense sciences, for government agencies. Through the David W. Mann Company, a Division located in Burlington, the company develops and manufactures such instruments as microdensitometers which are used in photographic analysis work to measure optical density and position on photographic films and plates. This analysis is utilized in missile and space studies, in photo reconnaissance work, in astronomy, and in quality control. Other instruments produced by Mann are optical comparators which are used in photo reconnaissance and lunar mapping and photomask systems used in the production of integrated circuits.

Additional GCA operating divisions and subsidiaries are: Vacuum Industries, Inc., Somerville, producing vacuum metallurgical processing equipment and systems; GCA Technology Division, Bedford, which performs research, development, and manufacturing in programs based on the sciences related to the earth, its environment and space, including some measurement instruments; and GCA Viron Division, Minneapolis, which develops inflatable and rigidized structures used as personnel shelters, as solar energy collectors, for lifting and hauling, and other purposes.

Northrop Corporation, which employs more than 1,500 persons in its plants in Norwood and Needham, makes high precision miniature and inertial gyros, sophisticated navigation systems, and special equipment for military use.

Allied Research Associates, Inc. in Concord specializes in the design and fabrication of enviromechanical test equipment which includes slip tables for vibration testing, specialized testing machines for tension, compression, and creep testing of metals, plastics, and rubbery materials, as well as instruments to measure displacements and strains. Two major fields it serves are structural mechanics and geophysics.

Centrifuges, instruments which use centrifugal force to separate materials of different densities (or specific gravities) where at least one of the materials is a liquid, constitute one of the most basic and necessary tools that the research scientist has at his command. The demand for them has grown in direct proportion to the expansion of medical and scientific facilities.

The International Equipment Company in Needham Heights, founded in 1901 in Cambridge as the International Instrument Co., is the world's oldest and largest manufacturer of centrifuges. It began as a small machine shop supplying Harvard University's professors and scientists with specialized apparatus for laboratory experimentation. Today International centrifuges can be found in practically every hospital and university laboratory in the country. The development of dried blood plasma techniques, much publicized during World War II, owes its success primarily to these centrifuges. They have also played an important role in the development of vaccines and antibiotics.

Centrifuges are now widely used in the testing of small electronic components. Small semiconductors are placed in centrifuges and spun at speeds as high as 60,000 revolutions per minute to approximate the "high G" forces necessary to meet government specifications in the building of space vehicles, defense missiles, radar and tracking devices.

A company in Canton, Instron Corporation, devotes its efforts to the design of instruments for testing materials for stress and strain. Started during World War II by two M.I.T. graduates, its first customer was the United States Air Force. Instron was asked by the Air Force to investigate the physical properties of nylon for parachutes to replace the formerly used silk ones. A wide search failed to unearth any instrument or device that could do the job, so they invented one. The instrument is now made by Instron in both floor and table models. It is a delicate and highly accurate electromechanical unit that, by utilizing related equipment and accessories, can test the strength per inch, per pound, per grain, or per anything of such diverse substances as steel and plastic, wood and paper and textiles. It can also record the results graphically on a chart. One of its applications was to test the properties of a strand of human hair so that a cosmetics company could market a better shampoo.

The Jarrell-Ash Co. in Waltham is one of the leading companies in the United States engaged in the manufacture of scientific instruments used for analytical purposes. Among the instruments this firm makes are vacuum atom-counters,

spectrometers of various types, dissolved oxygen analyzers, and laser microprobes and recording microphotometers.

The third category of instruments made in Massachusetts include such instruments as surgical, medical, dental and diagnostic instruments. It is readily understandable why the manufacture of medical instruments should be a thriving industry in Massachusetts. Boston is a leading medical center and people from all over the world come to its hospitals and clinics for treatment. In addition, New England has many large medical schools and institutions that train medical technicians as X-ray specialists, dental assistants, and medical laboratory workers.

A leader in the medical instrument field is the Sanborn Co. in Waltham which employs 950 people. This firm, now a division of the Hewlett-Packard Co., is one of the country's largest manufacturers of medical diagnostic instruments. It is also a large and growing producer of precision oscillographic recording systems and related instruments whose applications are many and too technical to attempt to describe here. The company was a pioneer in the development of electrocardiaphic instruments used by doctors to determine heart action.

Epsco, Incorporated of Westwood pioneered the development of high-speed, high-accuracy data handling-systems, and particularly the analog to digital converter. These systems are used wherever large volumes of test data must be measured and recorded in computer language, such as in government and industrial research laboratories and missile and space programs. The company employs 200 people and its product line includes instrumentation amplifiers, electronic multiplexers, a broad line of analog to digital converters, and digital logic modules.

Medical specialties made by The MacBick Co. in Wilmington include highly complicated instruments and systems for urological and surgical irrigation, blood collection and typing.

Other products in this category, produced mainly by smaller companies, are surgical instruments used on the operating table, hypodermic needles and syringes, artificial lungs for use in open heart surgery, medical computers, and apparatus used for research and teaching in physiology and allied sciences.

There is considerable overlap between the medical division of the instrument industry and the fourth major segment of the industry, that which makes optical instruments. Many optical instruments are designed for use of the medical profession. The optical instrument companies also make optical products for the consumer, such as eyeglasses and cameras. The story of manufacture of cameras in Massachusetts is told in the chapter covering the Recreation industry.

The beginning of the eyeglasses industry in the United States occurred in Southbridge in 1833, when William Beecher, founder of American Optical, began making silver-framed spectacles in a small shop with a staff of four people.

Today, American Optical manufactures more than 2,000 different products, and employs more than 10,000 people in the United States. Nearly 5,000 are employed at the company's Southbridge industrial complex alone.

In addition to manufacturing eyeglasses, the company produces sunglasses, ophthalmic, medical, and scientific instruments. American Optical personal protective products are used by industrial workers the world over. These include safety glasses, goggles, clothing, helmets, respirators, and hearing protectors.

American Optical Company's Research Division has made important contributions to industry and science. Among these are the glass rods used in laser devices. Laser is the amplification of light through a special glass rod, into a highly intensified beam. The beam can be used to cut and weld metal, in a surgical operation, or to transmit a message billions of miles.

A recent laser development by American Optical is the Laser Photo-Coagulator, a medical instru-

Image characteristic of Air Force photographic lenses weighing up to 700 pounds and having focal lengths of up to ten feet can be examined on this lens test bench.

ment used to repair damage to the human eye. A powerful beam of light is directed into the patient's eye and the damaged area is "welded," instantly and painlessly. Components produced by American Optical Company are being used to track missiles and satellites through space. Fiber optics, millions of tiny fibrous strands capable of transmitting light, is another product of American Optical Research. This amazing device enables men to see into heretofore inaccessible areas such as the human heart, the inside of a missile fuel tank, or the engine of an aircraft in flight.

Another company in Southbridge, Mosaic Fabrications, Inc. has rapidly become an important producer in the new technology of fiber optics. Glass is the material that forms the basis of this new industry, and it is spun into such superfine strands that six million of them are needed to make a bundle only one-half inch in diameter. The unique ability of these tiny threads to carry light and images from one end to another provides many unusual applications in military photography, medicine, and industry.

Hilsinger Corporation in Plainville is a large producer of aluminum

Efficient operation of electronic equipment depends on careful assembly of many complicated circuits.

eyeglass frames and sunglasses. This firm acquired the long-established Evans Case Company and under the Evans name it makes an extensive line of pocket and table cigaret lighters.

Diffraction Ltd. in Bedford makes lenses for movie cameras costing as much as $100,000 apiece and also produces sophisticated reconnaissance lenses, infrared lenses and laser optics.

The principal designer and manufacturer of submarine periscopes for the United States Navy is Kollmorgen Corporation of Northampton. Both missile firing Polaris and conventional submarines rely on Kollmorgen periscopes to observe from a safe depth conditions on the surface of the sea, to navigate with pin-point accuracy through observation of the stars, and to acquire other information useful in warfare. Kollmorgen also makes optical instruments used to align everything from a lathe bed to an airplane wing, with accuracies as close as a few millionths of an inch; among these is an instrument which "looks at" the carriage of a machine tool and automatically plots any error in its travel. Other products of this versatile company include optical devices for exploration of outer space, borescopes for examining the interior of gun barrels, motion-picture lenses, and a wide variety of instruments for military and industrial use.

Instrument Development Laboratories in Attleboro, a Kollmorgen subsidiary, is the leading supplier of instruments for the automatic measurement and control of color in industrial production. Paint, paper, printing, textile, and plastic industries use these instruments to make sure that the color of their products will remain true with an accuracy far greater than that possible with the human eye.

Other companies in the optical industry division of instruments in Massachusetts are also highly specialized. General Electric's Ordnance Department in Pittsfield makes electro-optical equipment, as does Image Instruments, Inc. in Newton. Pyrotector, Incorporated in Hingham makes infrared optical fire detection systems based on ratio detection of infrared related to visible radiation, and makes optical smoke detection systems for aircraft industrial, commercial, and residential use.

Stocker and Yale, Inc. in Marblehead, manufactures a line of optical projectors and comparators which are used to magnify any irregularities in the shape of a machine part such as a gear. These irregularities are shown on a special screen. R. S. Wilder, Inc. in Waltham is the first and oldest Massachusetts manufacturer of optical projectors in this field.

A. D. Jones Optical Works, Inc. in Burlington was founded in 1925, and its history is typical of the ever-increasing demand for high-precision optics. The company started by making relatively simple optical parts for basic scientific instruments, but has since found that the growing scientific community is constantly finding new needs and applications for glass and quartz, and new requirements for extremely fine dimensional accuracy in metallic and crystalline components. The work list at this and other optical concerns in Massachusetts now includes delicate configurations of materials such as strontium titanate and indium antimonide, among more routine items of pyrex and glass.

The optical industry in Massachusetts has also been responsible for the growth of a number of companies which manufacture component parts ranging from tiny screws to eyeglass frames and lens

blanks. A group of these companies is clustered around the Southbridge area but others are scattered around the state. Among the larger companies are Webster Lens Company in Webster, Marine Optical Manufacturing Company in Boston, Univis-Bishop Company in North Attleboro, United Lens Company in Southbridge, Fairfield Optical Company in Mansfield, Simonds Machine Company in Southbridge, and J. I. Morris Company, also in Southbridge. H. L. Bouton Company in Buzzards Bay specializes in welding goggles and other industrial eye protective devices.

There are other instruments made in Massachusetts that, strictly speaking, cannot be exactly classified under any of the four main divisions described in the foregoing pages of this chapter. One such group is surveyors' instruments. C. L. Berger and Sons, Inc. in Boston has for almost 100 years manufactured surveying instruments of all types. These have been used on some of the most famous building projects in history such as San Francisco's Golden Gate Bridge, the Panama Canal, T.V.A., and the United Nations Building, to mention but a few. Special instruments were developed for use in the aircraft industry during the last war and the firm is now designing and manufacturing special instrumentation for space and defense. Other items made by this concern include precise leveling indicators for rocket launchers, missile checkout and alignment instruments, precision level vial assemblies capable of determining a level condition within one second of arc (¼ inch in one mile!). In addition the company has the ability to graduate scales and circles accurate to one second of arc. They also supply industry with optical alignment equipment for bore sighting radar antennas, compass calibration equipment for military aircraft and optical alignment equipment for the precise check-out of machine tools.

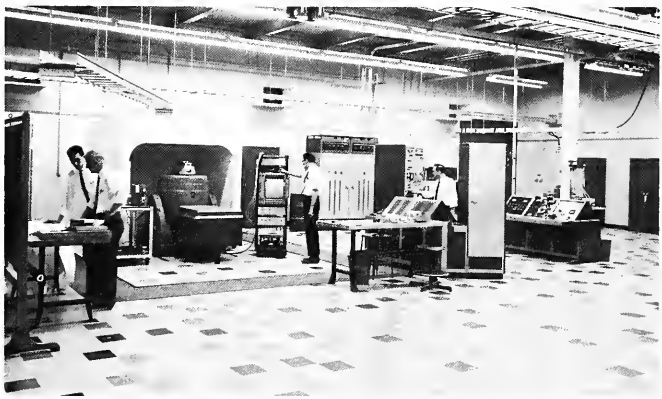
Compasses, marine instruments used in navigation, have been made in Massachusetts for many years by the firm of E. S. Ritchie & Sons in Pembroke. The founder of this firm, Edward S. Ritchie, first manufactured magnetic compasses in Brookline in 1850. Fathometers, instruments that tell the depth of water under a ship's hull and register the depth in fathoms on a dial, are produced in Massachusetts by a division of the Raytheon Company. Also in the field of navigation is Inland Controls, Inc. of Boston, a division of Kollmorgen Corporation, which produces rotating "rate tables" needed for the testing of gyroscopic instruments.

One might not ordinarily associate the manufacture of jewel bearings with the instrument industry, but the fact is jewel bearings constitute an important division of many instruments. They are used primarily in low torque instruments and control devices wherever low friction, non-magnetic properties, and long life expectancy are essential requirements. They are manufactured in large quantities for the instrument industry by Richard H. Bird & Co. in Waltham. This company was founded in 1913.

Invention may be mothered by necessity but its sire is ingenuity. Inevitably, ingenuity requires research and the progress of research is measured by precise instruments. As products become more and more complicated, accuracy requirements grow more exact, establishing a need for precise control instruments.

Massachusetts, in the early nineteenth century, had begun pioneer work in optics which led to the development of research instruments. The production of watches and clocks paralleled the growth of instrument manufacture, and research in lenses contributed to the improvement of photographic equipment. The first camera to produce immediate prints within the camera resulted from years of experimentation in a Massachusetts laboratory.

A new age demanding new instruments for control, research or recording will find skilled hands ready in Massachusetts.



Test underway on Sine and Random Vibration Exciter capable of operating over a range from 5 to 3,000 cycles per second.

The Space Industry

Massachusetts ingenuity probes the new "ocean"

Space is the great adventure of the 20th century, and Massachusetts, through the skills of its scientists, engineers and technicians, has a starring role. So great has been the state's contribution to the space effort, and so significant is its potential that the National Aeronautics and Space Administration chose to establish an Electronics Research Laboratory in the Greater Boston area at a cost of $61 million. NASA knows the capability of Bay State universities and industry and wants to be as close as possible.

Its important role in the space industry is a fitting role for a region that pioneered the development of the clipper ships that sailed the world's trade routes. Today Massachusetts ingenuity goes into space, "the new ocean," as President Kennedy called it.

When did the space age begin? Some claim it was October 4, 1957, the day the Soviet Union orbited the first Sputnik, whose beeping signals were picked up on recorders developed by the Sanborn Division of Hewlett-Packard Company, of Waltham. Others argue that it was the day Germany perfected its deadly V-2 rockets to use against the British Isles.

There are those, however, who like to go back to 1918, when a physics professor at Clark University in Worcester submitted a 69-page paper to the Smithsonian Institution. The professor was Dr. Robert Hutchings Goddard. His paper was entitled "A Method for Reaching Extreme Altitudes." Toward the end of his scientific treatise Dr. Goddard indulged in some speculation. It might, he suggested, some day be possible to land scientific instruments on the moon, given a large enough rocket. The newspapers ridiculed him for suggesting such a fantastic thing.

Ignoring the comments, Dr. Goddard continued his research and by 1926 was ready to launch the world's first liquid-fueled rocket. The flight took place at his aunt's farm in Auburn. It was far from spectacular, reaching a height of 41 feet and traveling 184 feet, but it did prove the theory upon which modern rocket propulsion is based.

By 1935, his rockets had reached speeds of 700 miles an hour and heights of 7,500 feet. The physics professor from Worcester was to go down as the father of modern rocketry. Thus, Massachusetts ingenuity was involved from the beginning.

The United States entered the manned space field with the short sub-orbital flight of Alan B. Shepard, Jr., on May 5, 1961. The Navy Commander's flight in the spacecraft Freedom 7 lasted only 15 minutes but in effect it was the first step in a journey that will land an American on the moon in the 1970's. A highly precise tracking antenna designed, developed, and manufactured by General Electric in Pittsfield is a major component of a missile radio-command guidance system used successfully by the Air Force for this and many other ICBM flights.

Other shots followed in the series known as Project Mercury. In July of 1961, Major Virgil I. Grissom essentially duplicated Shepard's flight. Then, on February 20, 1962, Marine Colonel John H. Glenn, Jr. orbited the earth three times in his spaceship, Friendship 7.

Honeywell Radiation Center (formerly Boston Division) on Soldiers Field Road in Brighton produced the gyros, called Golden Gnats because of their small size and color, for the automatic stabilization and control system for all the Mercury spacecraft. In addition, this Honeywell unit designs, develops, and fabricates infrared detectors, star and planet trackers, lasers, special purpose radar systems, and other electro-optical and electro-magnetic devices.

The Glenn flight pointed up one of the many industrial paradoxes of the space age. The flight was made possible by the expert blending of hundreds of unusual components into reliable systems. Yet, in the end, the mission relied upon a much more mundane product—rope.

Samson Cordage Works on Boston's Atlantic Avenue made the braided nylon that pulled Colonel Glenn and his capsule from the Atlantic. Another Bay State firm, the Sprague Electric Company of North Adams, has made solid-electrolyte capacitors (electric condensers) used in the electronic guidance and communications systems of Mercury spacecraft. Tantalum is an exotic space-age metal. Sprague Electric has furnished these types of capacitors as well as electronic interference filters for practically every satellite and missile

system which has been built so far. The company is an acknowledged specialist in high-reliability electronic components.

America's current manned space project is Gemini, named for the third constellation of the zodiac which has been represented pictorially since ancient times as the twins Castor and Pollux, sitting together in the sky. The astronauts, who sit side by side in the Gemini capsule, rely heavily on Massachusetts equipment. In America's first successful two-man Gemini flight in early 1965, the space suits worn by astronauts Virgil I. Grissom and John W. Young were also Massachusetts-made products. Major Edward White, the first American to walk in space on the Gemini 4 flight, also wore one of these special suits. Manufactured by the David Clark Company of Worcester, these intravehicular space suits weighed approximately 24 pounds and cost approximately $28,000 each. For the initial flight, each astronaut was provided with three suits: one for training, one for the mission, and a third as a "back-up" in case the primary flight suit was damaged or failed to operate properly before the flight. A. R. Hyde Sons Company of Cambridge made the custom-fabricated boots worn by the astronauts.

An electronic encoder made by Epsco, Inc. of Westwood is a critical part of the data handling and telemetry system that records the performance of the Titan launch vehicle.

Basic power source in the capsule is a pair of fuel cells that produce electricity through the chemical reaction of oxygen and hydrogen. The cells are made by General Electric Company in Lynn. In addition to their weight advantage, they make drinking water as a byproduct.

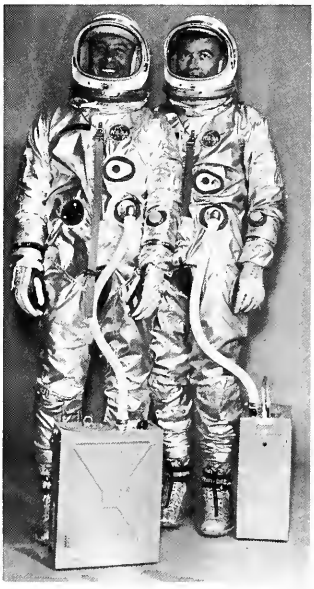
Project Gemini calls for development of orbital rendez-vous techniques. The plan is for the two astronauts to mate their spacecraft with an Agena space vehicle while in orbit. They will do this through optical alignment techniques utilizing high intensity flashing lights on the Agena. These lights will be made by the Bedford firm of Edgerton, Germeshausen and Grier, Inc., which currently has flashing beacon systems aboard operating geodetic satellites.

Gemini is the next-to-last step in the nation's journey to the moon and in its final stages it may see astronauts in orbit for as long as a week. The biggest project of the 60's, however, is Project Apollo, which hopefully will end with a lunar landing in 1970 or soon after.

Apollo is one of the greatest technological undertakings ever attempted by man. Its magnitude and requirements are staggering. For instance, the Saturn V launch vehicle will be 280 feet tall. At liftoff from Cape Kennedy, it will have 7½ million pounds of thrust.

Saturn's myriad parts weigh from a few ounces to thousands of pounds. Many require special manufacturing equipment, such as the 50,000 ton press at the Wyman-Gordon

Astronaut Major Edward White strolls in space as Gemini 4 orbits the earth.



Astronauts Virgil I. Grissom (*left*) and John W. Young pose in their Massachusetts-made space suits.

Company in Worcester which turns out aluminum hold-down posts for the Saturn engine. Each post weighs 1,750 pounds.

When it leaves the earth, the Apollo configuration will weigh six million pounds. On board will be three astronauts and aiding them throughout the trip will be a Raytheon computer less than a cubic foot in size and weighing under 70 pounds. Its role: to navigate the ship to the moon and back.

Only two of the astronauts will land on the moon. They will ride in a lunar excursion module (often called LEM or bug, for short), which will detach itself from the Command Module while in a lunar orbit.

At R.C.A.'s Aerospace Systems Division in Burlington, engineers and scientists are busy designing radar systems, communications systems, and stabilization and control equipment. In effect, R.C.A. will design all the electronics required by LEM for its descent onto the moon and return to the Command Module.

Also on R.C.A.'s project list is development of an umbrella-like space antenna, technically known as EVA (for extra vehicular antenna). It will be a light-weight antenna which the first astronaut on the moon will raise like an umbrella until it forms a 10-foot dish. This he will use in communicating with his colleagues on Earth.

Getting on the desolate surface of the moon is, of course, only half the battle. Getting back will be quite a project, too. Actually, only 10,000 pounds of the original 6 million pounds will arrive back on Earth, and to do so it will survive some appalling temperatures.

A returning Apollo capsule will approach the earth at a speed of almost seven miles a second. When it blasts into the earth's atmosphere, the shock and friction of the collision between the spacecraft and atmospheric gases will turn the capsule into a fiery meteor, and temperatures in the highly compressed gases just ahead of the vehicle will soar to 100,000 Fahrenheit, nearly ten times that of the sun's surface. Fortunately, the shock wave created by re-entry will dissipate most of this heat. Nevertheless, temperatures on the surface of the spacecraft will range up to 5,000 Fahrenheit, still hot enough to melt most materials known to man.

To solve the problem of protecting three astronauts from the inferno raging outside the walls of their cabin is the assignment given to Avco Corporation's Research and Advanced Development Division in Wilmington. The assignment also has other complications. Booster capability places a severe weight limitation upon all elements of the Apollo spacecraft, including the heat shield. And the maximum temperatures encountered during re-entry will be different on various parts of the heat shield (due to such surface features as windows, hatches, antennas, abort tower holes, etc.). This means that the heat shield material must be light weight to begin with, and its thickness must be precisely enough to meet the design requirements at each point on the surface, with no excess material anywhere.

To solve this problem, Avco/RAD has developed a lightweight plastic heat shield which is called a charring ablator. It dissipates the surface heat by charring slowly during re-entry. It will insure that shirtsleeve temperatures are maintained inside the craft during re-entry. The problem of contouring the heat shield to the varying, and precise, thicknesses required—too demanding a task for the most skilled of human operators—has been solved by means of computer-controlled giant lathes, which automatically contour the four basic sections of the heat shield to exact specifications. Since the lives of the three astronauts depend upon the integrity of the heat shield, new inspection methods, including X-ray and ultra-sonic equipment, have been evolved to insure that there are no minute gaps, voids, or flaws in the finished ablative heat shield installed upon the sub-structure of the Apollo Command Module.

Avco/RAD is also involved in programs looking beyond Apollo, particularly those aimed at the exploration of Mars. It has conducted mission and design studies for NASA on the Voyager program which would land unmanned vehicles on Mars in flights beginning in 1971. These lander vehicles would contain scientific instrumentation designed to answer the age-old question: "Does life exist on Mars?" In connection with its variety of projects concerning planetary exploration, Avco/RAD has built such diverse and unique tools as a 14-inch full-color globe of Mars and a huge Astrolab facility for simulating the stars, planets, and sun in the development of guidance and control systems.

Also involved in Project Apollo is A. W. Chesterton Company of Everett whose mechanical seals will be used in the moon vehicle.

But manned flight is not the only area of this country's space endeavor. Scientific probes, such as the three successful Rangers which photographed the moon, are equally important in the total space effort. Because of its sophisticated space industry, Massachusetts has played a vital role here, also. As a matter of fact, there is already a little piece of Massachusetts on the moon. A

crystal filter made by Damon Engineering, Inc. of Needham was aboard the Ranger 7 which crashed on the moon July 3, 1964. It played an important role in tracking and guidance. Similar filtering devices from this company have been in all the Ranger shots which are currently on the moon's surface. Other filters and special components are utilized in such programs as Apollo and LEM.

Versatile long-range radar systems that probe deep into space have been pioneered by the Bedford Division of Sanders Associates, Inc. This phased array radar can search and track at the same time. For instance, if its target is satellites, it can lock on to some while searching out the remainder.

Prominent among the several Massachusetts suppliers to aerospace contractors is the United Shoe Machinery Corporation. The Harmonic Drive Division of this diversified Boston-based firm made the drive mechanisms that were used to control the extension of the "wings" of the Pegasus satellite orbited to study meteorites. The wings unfold on signal to a full 96-foot wing span. The USM division at Beverly produces mechanical drives and speed reducers based on a mechanical principle invented in 1954. Harmonic drive mechanisms are also used as satellite instrument drives providing a durable speed reducer able to withstand the rigors of aerospace use. The unit permits motion transmission through a hermetically welded seal and precise relationship between input and output during a long operating life.

The state has been well represented in the Pegasus satellites, the second of which was launched in the spring of 1965 to measure concentration of meteoritic particles in space. United Shoe Machinery Corporation's Beverly plant again supplied the satellite's transmission equipment; Di-An Controls of Boston made the memory core which stores information until it is telemetered to ground stations; Adcole Corp. of Waltham provided a solar sensor which determines the position of Pegasus relative to the sun.

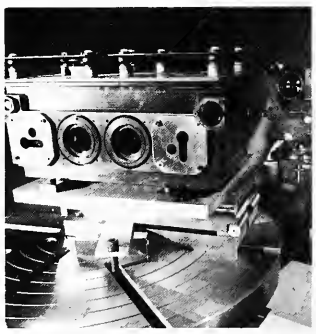
Several Massachusetts companies have brought space down to earth. National Research Corporation of Cambridge, High Vacuum, Inc. of Hingham, and Vacuum Industries, Inc. of Somerville, a subsidiary of GCA Corporation, produce high vacuum chambers. High Voltage Engineering, Inc. of Burlington makes charged particle accelerators. With these laboratory tools it is possible to simulate the conditions of outer space and subject satellite components to rigorous tests. Ion Physics Corporation, Burlington, for example, performs space radiation environment simulation tests under vacuum and cryogenic, or low temperature, conditions. Thermo Electron Corporation of Waltham is busy working in the exciting new field of thermionic conversion, a process which produces electrical energy directly from heat. Such a system, using the sun, a radioisotope, or a nuclear reactor as a heat source, may one day power space vehicles.

Potential malfunctions detected in such tests can save time, money, and more important, perhaps even lives. Working to prevent malfunction is Instron Corporation of Canton. This firm's testing devices put materials through push and pull stresses while recording the strain each force produces.

Intense noise and vibration can cause trouble, too. Bolt Beranek and Newman Inc. of Cambridge, a research, development and consulting firm, is working in three important areas of this problem. First, they are studying the effects on spacecraft structures of the intense noise and vibration levels produced by large rocket boosters. These high levels can cause structural damage to the vehicles, hearing damage to the operators, and irritation to neighboring communities. The company is currently studying the acoustical behavior of space flight structures such as the Apollo Command Module.

A second subject of concern is human engineering of spacecraft: the vehicle must be designed so that man and machine work together as an efficient partnership. To do this the designer must know and take into consideration the characteristics of the human operator. BBN is doing basic psychological research on how people act in dynamic control situations, how they detect signals, how they pay attention to a number of simultaneous events, and how they respond to acoustic stimuli.

Third, BBN is developing special instrumentation to support these project areas. In the first area, a computer-operated monitoring system to measure rocket noise is being developed and installed at Marshall Space Flight Center, Huntsville, Alabama. In the second area, an



The AOSO Fine Sun Sensor, mounted on the left, being tested by an evaluation engineer looking through a theodolite.

attitude reference and rate indicator of a new type for spacecraft is being designed and built.

Trans-Sonics, Inc. of Burlington specializes in measurement and control. Hundreds of their instruments are in earth orbit, on the moon, or exploring the environments of Venus and Mars. Trans-Sonics' temperature, pressure, and propellant measuring systems are used for scientific data collection on the Saturn-Apollo vehicle. Jackson & Moreland, a Boston engineering firm, designed a lunar landing research facility which has been installed at the National Aeronautics and Space Administration's Langley Research Center in Hampton, Virginia. It is used to perform experiments in the technology of soft lunar landings under conditions of simulated lunar gravity.

The Advanced Orbiting Solar Observatory will carry an electro-optical eye developed and produced by Honeywell Radiation Center in Brighton. Technically called the AOSO fine sun sensor, this instrument will scan the sun in much the same way as the picture is produced on a television screen. With the precise information provided by the sun sensor, telemetered commands to the solar observatory will be fed to the guidance and attitude control system. The same sensor will keep the vehicle pointed at a 210,000 square mile area on the sun's 2,700,000,000,000 square mile surface.

Worcester's Norton Company is producing ceramic coating materials to resist the effects of heat. Its Rokite ceramic coatings are used in the thrust cone of the Agena rocket to form a barrier between the hot gas stream from the engine and a thin metal substrate.

Kollmorgen Corporation, Northampton, designed ultraviolet rocket spectrophotometers to ride aboard rockets and sample the region above Earth's atmosphere. These instruments may uncover new galaxies which radiate predominantly in the ultraviolet spectrum.

At least two Massachusetts firms are making specialized telescopes to work in space. In Needham, at Sylvania Electronic Systems, a division of Sylvania Electric Products, Inc., work is under way on a telescope, spectrometer, and data processing and programming equipment for an Orbiting Astronomical Observatory due for launch in 1966. The equipment will measure light absorption characteristics of interstellar gas and dust clouds from which, scientists believe, stars are formed. At Sylvania Electronic Systems facilities in both Waltham and Needham, the company is building a transportable ground station for advanced satellite communications tests under a multi-million dollar NASA contract and is developing electronic display instruments that will help United States spacemen land safely on the moon.

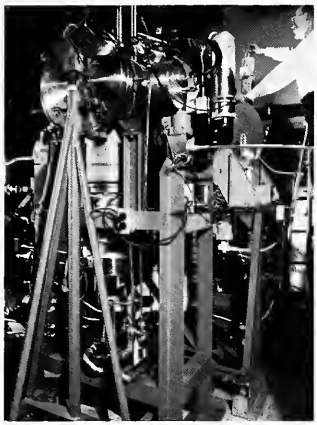
Sylvania has conducted for NASA a feasibility study of a system in which an orbiting satellite would collect weather and oceanographic information from unmanned buoys, balloons, and weather stations. For the Air Force, Sylvania developed a wideband laser modulator for aerospace communications. Both projects were conducted at Sylvania's Applied Research Laboratory, Waltham. American Science and Engineering, Inc. of Cambridge has developed an X-ray telescope. This device is scheduled for inclusion in an Orbiting Solar Observatory to obtain a high resolution map of the sun. Other instrumentation will be utilized in the development of an "all sky X-ray map."

GCA Corporation of Bedford, formerly Geophysics Corporation of America, was selected to standardize and build sounding rocket components and nose cone housing for rockets. The company is providing complex combinations of instruments in single payloads for a variety of United States and foreign rocket programs being conducted during International Quiet Sun Year (IQSY). This is, however, only one segment of GCA's overall efforts in the space field. The company regularly ranks among the top eighty prime contractors in the entire nation in dollar volume of contracts to NASA. Work at GCA in this field ranges from studies to determine the temperature of Mars and Venus to a new type of telemetry system for tracking rockets.

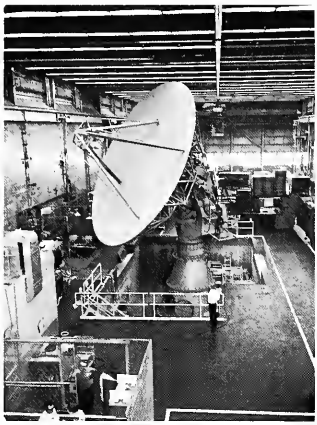
BLH Electronics Division of Baldwin Lima Hamilton, Waltham, has developed and manufactured high speed thermocouple and resistive-type temperature sensors for missile skins and nose cones.

Computer Control Company of Framingham engineered a scientific data conditioning system, actually a small assembly of more than 3,000 electronic components, which controlled the sensing of the scientific instruments and assembled the scientific data for transmission back to Earth as Mariner II flew past Venus. An advanced version of this equipment performed a similar function in the Mariner-Mars.

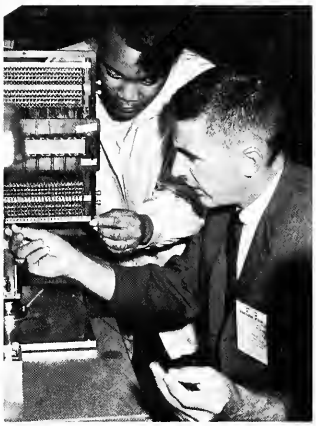
Antennas developed and manufactured at General Electric's Ordnance Department in Pittsfield are today playing an important role in the nation's space program. A tracking antenna produced at Pittsfield is a major component of the radio guidance system used by NASA and the Air Force to launch the first two-man Gemini spacecraft into orbit. Previously, it was used successfully on all Mercury



Prototype of a system capable of duplicating interplanetary space vacuum for research and testing.



Three-axis shipboard tracking antenna can track a satellite anywhere within a hemisphere.



Air Force Captain William A. Anders, of the Apollo astronaut team, sits in on production of on-board guidance computers.

orbital and suborbital missions by astronauts. The antenna has also been used to track every U.S. shot to hit the moon and also on the Venus probe. Developed originally for the Air Force's Atlas ICBM program, it operates with such smoothness and accuracy that its movement is almost impossible to perceive. Its precision has been compared to that of a fine watch.

A shipboard, three-axis antenna for tracking communications satellites for the Syncom program was developed and manufactured by G.E. at Pittsfield. Now installed aboard the USNS KINGSPORT, this 58,000-pound antenna has been used to track NASA Syncom communications satellites into synchronous orbit 22,300 miles above Earth. Its unique, three-axis design permits tracking at any angle above the horizon while maintaining uninterrupted communications with the Syncom satellite. Even in highly turbulent seas, the antenna maintains its accuracy as the ship rolls and pitches. The antenna has a 30-foot reflector and its full height is approximately that of a five-story building.

Electronics Corporation of America builds photoelectric equipment which controls giant power plants throughout the world. Its infrared surveillance and guidance devices are used in a major satellite program and for military weapons.

Atkins & Merrill, Incorporated, Sudbury, make sophisticated reinforced plastic parts for missiles and aircraft, including de-icing and heating structures. This firm is also among NASA's largest suppliers of aerodynamic models used in NASA research and testing programs, and static models which are used in NASA's public information program. The full-size models of the Apollo and Gemini spacecraft and the LEM vehicle displayed in the Space Park at the New York World's Fair, as well as the 20,000 square-foot NASA exhibit at the Seattle World's Fair, were all produced by this company.

In the vastness of space it is sometimes difficult to realize that the things which spell the difference between success or disaster for satellites or even manned spacecraft are all very small: a tiny bit of "dust," hurtling at blinding speed, that can destroy a space ship, or the change in direction of fractions of an inch that mean missing a planetary target by thousands or millions of miles. The device which accurately senses minute difference in acceleration, direction, or even in the long-range gravitational pull of distant bodies, is the gyro, manufactured in Norwood by the Precision Products Department of Northrop Nortronics.

These are just a few of the Massachusetts firms that are blazing new technological trails in the massive attempt to conquer space. There are others, many others, making equally important contributions. The number of companies involved is a tribute to the caliber of the people of Massachusetts and their industry. It is an involvement of which every Bay State resident can be proud.

The Paper Industry

Since 1730, a world of paper

It was an insult to the Crown of England that upstart paper-makers in the Massachusetts Bay Colony should interfere with British paper-makers' profits by producing in just one year paper "to the value of two hundred pounds sterling." The seed of free enterprise, however, was too deeply implanted to be disturbed by the Crown's reaction and, in a few years, paper mills were being built along streams from Milton to Dalton.

Most of us think of paper as a "throw-away" product. We receive a Christmas present, unwrap the package, and discard the wrapping. We get a letter, read its contents, and toss it into the wastebasket.

But there is one kind of paper, a kind manufactured almost exclusively in Massachusetts, which we never throw away. That is the paper on which the United States Government prints its currency, our "folding money."

Since 1879, Crane & Co. has been making currency paper for the United States Government in the Berkshire County town of Dalton. The paper is produced in a special mill at the Crane plant which is constantly protected by Federal guards. When the blank paper is shipped to Washington for engraving it is guarded as closely as if it were money. Just to have in one's possession a piece of this blank paper as large as a dollar bill is a punishable Federal offense.

The fact that the Federal government year after year has turned to this same source for its currency paper is a tribute to the skill of Massachusetts craftsmen. This paper has to contain special threads of red and blue fibers to foil counterfeiters and it must be exceptionally strong to stand up under hard usage in trade and commerce. One of the requirements is that the paper shall be capable of withstanding 4,000 double folds in the same place without breaking.

Currency paper is only one of literally hundreds of kinds of paper made in the Bay State. In speaking of paper, it is safe to say, "You name it, Massachusetts makes it."

A world without paper is impossible to imagine. Books, magazines, newspapers, letters, package wrappings, milk containers, egg cartons, even the simulated wood-grain panels that decorate the sides of station wagons, are paper products. America uses paper almost as it does water, food, and air: almost 500 pounds of it a year for every man, woman, and child. The makers of fine writing and printing papers as well as makers of specialty lines, ledger, onion skin, condenser, Bible paper, and industrial converter papers operate in many plants across the Bay State.

Paper is made from various cellulose fibers obtained from wood, cotton or other fibers such as hemp, jute, esparto, seed flax, and bagasse. The ancient Chinese invented it, and the process gradually made its way across Europe where paper was so scarce and expensive that its first use was restricted for religious works, hand illustrated and printed. Gutenberg, German inventor of movable type, first used it for printing as we know it today.

Paper-making consists of two major steps, mixing fibers with various additives, chemicals, and colors into a thin solution and then separating the fibers from the liquid. This was first done entirely by hand, the fibers, obtained from cotton cloth, being mixed with additives and water in a large container or vat. A mold, or framed screen, was dipped into the vat and lifted with a particular motion to form the sheet, and the easily removable liquid was drained from the fibers. This rough sheet was then rolled to remove any remaining liquid and to flatten it and give it a printing or writing surface. These sheets were then hung upon a line to dry, like laundry.

Henry Fourdrinier, capitalizing on an invention by Louis Robert in France in 1799, built the first machine to make paper in a continuous roll. This machine incorporated a screen-shaking device which is an integral part of today's paper-making machines, still known as "Fourdriniers." From this wire screen the barely coagulated fibers come off in a weak web form which is supported by a felt through heavy presses and dried by contact with steam-heated drying cans.

Cotton rags were in a great demand by paper-makers in the colonies and many paper-makers started their careers picking up cloth scraps from house to house to supply their mills. The first anti-British newspaper, *The Spy*, printed in Boston, fled from there to Worcester where it continued to rally the colonies by rebelling against taxation and oppression. *The Spy* survived, fed by paper

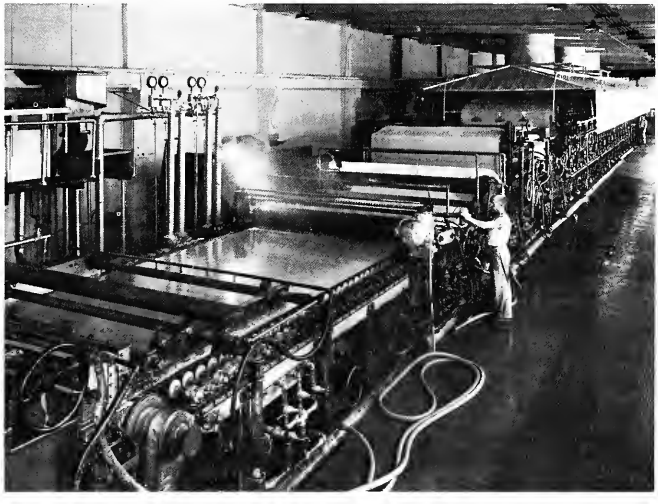
made by hand in a little mill, no longer in use, in the town of Upton, and eventually became the well-known central Massachusetts daily paper, the *Worcester Telegram-*and *Evening Gazette.*

The scarcity of cloth scraps created a great demand for another source of fibers. Shortly after the Civil War, Albert Pagenstecher, who had a small paper mill in Stockbridge, began experiments in making paper from wood pulp. He imported two wood-pulp grinding machines from Germany and established the first commercial wood pulp mill in the United States. His first sale of pulp was to the Smith Paper Co., at whose plant in Lee on March 8, 1867, the first practical demonstration of the new process in this country took place. Bay State inventors soon improved the process by shredding wood through chippers and treating the chips with acids to reduce them to fibers, or wood pulp.

Paper-making requires three essentials in almost limitless quantity: fiber, power, and process water. This latter is essential, as it requires up to 100,000 gallons of water to make a ton of paper. In the early days, too, water was not only essential for processing but it was also used to supply the power to run the mill. It is not surprising, therefore, to find most paper mills located on the banks of a river or stream. Gradually the manufacturers of vast quantities of paper, particularly newsprint, established themselves in northern Maine and Canada.

Massachusetts became the most

The first step in paper-making is the mixing of cellulose fibers with various additives, chemicals, and colors into a thin solution. This is accomplished in the "beater" which, at the same time cuts and crushes the fibers so they will bond together.



Paper stock begins its long journey through the Fourdrinier machine emerging at the other end as a finished roll of paper.

populous of the New England states largely because of the number and diversity of its manufacturers. As its cities expanded and more land was cleared for agriculture the resulting deforestation made competition difficult with the huge quantity producers. This not only removed the source of wood pulp but dried up many of the streams which had provided both power and process water. But early Massachusetts paper mills, many of them now more than a century old, continue to manufacture prosperously. The long-developed skills of workmen plus the business acumen of management carried them through the long evolution of paper-making when the trade was considered an art instead of a science. Maine and Michigan early established paper courses at their state universities and Massachusetts has followed suit at its own Lowell Technological Institute, which also maintains a pilot paper-making plant. Graduates of these schools have gradually transformed paper-making into an exact science. More highly developed machinery plus excellent instrumentation have replaced the thumb-and-finger feel of the finished sheet to determine quality.

The broad paper industry is composed of paper-making companies and paper-converting companies. The paper-makers produce the paper itself and sell it to the paper-converting firms which fabricate it into a seemingly endless line of products ranging from writing paper to parts for TV sets. Some companies are both paper producers and converters.

The paper-making companies are themselves roughly divided into three major segments: Producing paper from one, cotton products, two, from wood pulp, and three, those which make paperboard (cardboard) from the fibers in waste paper or other reclaimed material.

The first paper mill in Massachusetts was chartered by the Provincial Government in 1728, and started operations on the Neponset River in Milton in 1730. At the time, the Massachusetts General Court was anxious to develop a paper industry in the Massachusetts Bay Colony, so it granted the new venture a 10-year monopoly. Thomas Hancock (uncle of John), Daniel Henchman, a Boston bookseller and publisher, and A. Fanueil, along with some others, were the partners in this enterprise. Protection was promised them in exchange for their investment of capital, provided that during the first twelve months they produce 200 reams of *good merchantable* Brown Paper, 60 reams of which were to be printing paper, or approximately 4,800 pounds. The following year they were to make, in addition, 50 reams of writing paper, or about another 1,000 pounds. Although the mill had a difficult struggle at first, it continued to operate for many years, providing the colonies with a source of paper independent of England.

The original mill, through a series of succeeding partnerships, is linked with the history of the oldest existing paper concern in the United States, the Tileston & Hollingsworth Company, which for generations has produced quality book and writing papers in Boston. In 1801, Mark Hollingsworth and Edmund Tileston, as a partnership, purchased a mill in Mattapan which they acquired from a descendant of one of the early operators of the first mill in Milton. In 1912, the mill was purchased by the Penobscot Chemical Fibre Company, now the Penobscot Company. The Tileston & Hollingsworth Company now operates a large, modern paper mill in the Hyde Park section of Boston, not far from the original mill site. The present president, Amor Hollingsworth, is a direct line descendant of Mark Hollingsworth.

The year 1801 also marked the beginning of Crane & Co., the firm which makes currency paper. This company, too, has a link with the first Massachusetts mill in Milton.

Zenas Crane's interest in paper had been aroused by the fact that his older brother worked at the Milton mill. He himself took a job with a Worcester mill, and after learning the art of paper-making there, decided to go into business for himself. Seeking a site with an ample supply of clean water, he traveled through the Berkshires until he found a suitable location on the banks of the Housatonic River in Dalton.

Like other manufacturers of fine papers in the Berkshires, Crane & Co. still makes its line of quality writing papers from cotton and linen fibers obtained from rags, just as it did when Zenas Crane started the business. In olden days paper manufacturers used to collect rags from housewives to get the raw material for their paper. Nowadays they buy clippings from garment factories.

Each shipment of clippings is carefully examined at the paper mills before the cloth is fed into the machines which separate the fibers in the rags. No cloth made from synthetic fibers can be used. Presence of only a small amount of synthetics in a batch of rag pulp will ruin the quality of the paper.

Also in Dalton is the Byron Weston Company, now a subsidiary of Crane & Co., which has been a maker of business papers for over 100 years. Founded in 1863 to manufacture permanent ledger paper, the firm employs about 250 in the production of rag content

ledgers, bonds, indexes, and specialty papers.

Wood pulp, now the principal raw material for paper-making in most of the industry, is of comparatively recent origin. Early paper-makers in this country experimented with all kinds of fibers, including straw, hay, corn husks, and even seaweed.

Massachusetts is one of two major areas in the country producing rag-based fine papers. It shares honors with Wisconsin.

One of the smaller Berkshire mills whose paper has been well known in county courthouses and industry throughout the land since 1849 is L. L. Brown Paper Company of Adams. Its permanent record paper, made of 100% new white rag cuttings, is widely used for official permanent documents. The firm also makes other rag fiber papers for fine business stationery, insurance policies, legal papers, maps and charts, photographic base paper, diplomas, artist paper, graph paper, index bristol, and xerography papers. For many years this company produced currency paper for Nationalist China, because of its rugged endurance properties, and for the same reason its paper was chosen for payroll identification records for the armed services during World War II.

In Adams, the Paper Products Division of The Budd Company, with a work force of approximately 225, produces fine writing papers, printing papers, and industrial specialty papers. In Housatonic, the Rising Paper Company manufactures writing, announcement, bristol, and technical papers.

In Lee is the Peter J. Schweitzer Division of Kimberly-Clark Corporation, which makes the base paper from which carbon paper is produced. This plant also produces the tissue paper used as an insulating material in capacitors and other electrical apparatus. Other products are cigarette paper and tea bag tissue.

At South Lee, Hurlbut Papers, Industrial Papers Division of The Mead Corporation, makes some of the most unusual products in the industry. These include a paper which will not burn when a match is applied to it. It is made from ceramic fibers and it will resist heat up to 3,000 degrees F. Various kinds of paper filters used in industrial processes and in laboratories are also made at the South Lee plant. One type is used to filter radioactive particles out of the air at atomic energy plants.

In addition to the South Lee plant, Mead Corporation has two plants in Lawrence, one in Leominster, and another in Gardner. One of the Lawrence plants produces paperboard for folding boxes and display cartons. The other makes folding cartons and various types of containers for packaging food, hardware, and other consumer products. At Leominster the company makes heavy-weight printing papers and at Gardner it produces corrugated shipping containers.

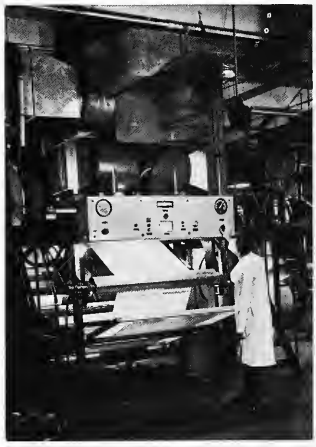
Erving Paper Mills, located in the town of Erving, is a leading manufacturer of paper napkins and other lightweight paper items. It is one of the largest printed napkin manufacturers in the world.

At Millers Falls the Millers Falls Paper Company makes its Old Deerfield Bond, a quality paper used for letterheads by leading business firms from coast to coast. The company also produces a special easy-to-erase paper on which typewritten letters can be obliterated by the use of an ordinary pencil eraser. Other Millers Falls products include cotton content onion skin paper, blueprint paper, tracing paper, and technical papers.

Nearby at Turners Falls, Esleeck Manufacturing Company produces papers made primarily from new cotton cuttings. This company is noted for its onion skin, manifold, technical and custom created functional papers built to fulfill specific requirements of today's modern industry. In the technical field it is one of the most prominent producers of a 100% rag paper known as All Rag Intermediate Paper, which is used as a master in whiteprint copying machines. Its onion skin and manifold papers are used for air mail stationery, legal documents, permanent records, and other forms where permanency and durability are required.

In Hardwick the Romar Tissue Mills Inc. manufacture facial and bathroom tissues.

Strathmore Paper Company, with mills in West Springfield, Woronoco, and Turners Falls, is a major producer of quality writing, printing, artist, technical, and more recently, industrial specialty papers. The company makes cotton, wood pulp, glass, and synthetic fiber papers.



Diazo sensitizing machines apply chemical coatings to rolls of paper, cloth and film for use in engineering drawings and office-copying applications.

The company's wide range of products includes high quality bond and writing papers for business and social correspondence, onion skin papers, air mail paper, and special paper for duplicating machines. The Strathmore mills make one of the broadest lines of text and cover papers for advertising pieces, and they produce the stock for wedding announcements, visiting cards, and greeting cards. The Bay State firm is one of the leading producers of base papers for blueprinting and other reproduction techniques and of fine papers for artists' use.

In 1961, the Strathmore business was acquired by Hammermill Paper Company of Erie, Pennsylvania. This company also owns Old Colony Envelope Company in Westfield.

Another long-time firm in the paper industry is the Southworth Company, of West Springfield, established in 1839, which produces typewriter papers, bonds, onionskin, and ledgers for printers and private consumer watermarks.

Premoid Corporation, West Springfield manufactures and converts technical and saturated papers, latex impregnated papers and plastic coated specialties for use in the automotive, shoe, millinery, pocket book and novelty industries.

From one continuous roll of paper this machine will print, cut, fold, and apply the seal gum to 42,000 envelopes an hour.

Holyoke has long been a center of the paper industry in Massachusetts. The site for the original paper mill was purchased from the Hadley Falls Company, which had erected a dam across the Connecticut River to supply power for various types of manufacturing. It is interesting to note that some of the directors of the Hadley Falls Company were skeptical about the paper-making project. They feared that the vibration of the machinery would collapse the brick walls of the mill which the sponsors planned to erect. However, in more than a century there has never been trouble with crumbling walls.

Located there now is the American Writing Paper Division of the Brown Company of Berlin, New Hampshire. This plant produces fine writing and printing papers, industrial and engineering papers, and paperboard.

The first paper mill established in Holyoke was the Parsons Paper Company in 1853. The firm that presently bears this name is a division of National Vulcanized Fibre Company and makes fine business and specialty papers. During World War II, Parsons Paper Company made a large part of the papers for the invasion currency used by the United States armed forces.

Texon, Inc., with plants in South Hadley Falls, Holyoke, and Russell, manufactures specialty impregnated papers for the automotive, luggage, and shoe industries.

Several big paper companies are located in Fitchburg, including the Paper Division of Weyerhaeuser Company (formerly the Crocker, Burbank Company) and the Fitchburg Paper Company.

For many years, until Curtis Publishing Company acquired its own paper mills in 1932, all the paper for the *Saturday Evening Post* and the *Ladies Home Journal* was made at the Crocker, Burbank plant in Fitchburg. Since 1932 the business has been diversified into many fields. The plant has made book papers for encyclopedias, dictionaries, and textbooks. It has also made a wide line of industrial converter papers, ranging from condenser paper, sandpaper, and shotgun shell paper to soap wrappers and filters. It makes paper for cigarette filters and automobile oil filters.

Included in the sale of the Crocker, Burbank Company to Weyerhaeuser was the former's wholly-owned coating division, the Louis DeJonge Company of Fitchburg, whose founder, a chemist, developed a coating substance from the curd of milk.

The Fitchburg Paper Company, a subsidiary of Litton Industries, Inc., produces plastic-absorbing papers for the manufacture of kitchen counter tops, table tops, TV cabinets, and decorative panels for automobiles. It also produces a wide variety of other papers, including base papers for special coating and use in copying machines and photography.

Falulah Paper Company in Fitchburg is a producer of paper boxboard and of clay-coated cardboards.

In Springfield, the Holyoke Card & Paper Co. also manufactures cardboards, coated and decorative papers. In Holyoke, Hampden Glazed Paper & Card Co. produces specialty coated papers and covers.

A Massachusetts paper firm whose products are known in every state east of the Rockies is Bird & Son, inc. of Walpole and Norwood, one of the oldest paper manufacturers in New England, if not in the nation.

Established in 1795 and still under management of descendants of the founders, this company is a major producer of asphalt roofing shingles. These are made from a heavy paper-type material called "roofing felt," impregnated with asphalt.

In its marketing area, covering two-thirds of the country, the company is one of the largest producers of asphalt shingles. The Bay State firm is the leading manufacturer of "wind-resistant" shingles, a type which has a thermo-plastic sealing material on each shingle to bind the overlapping shingle to it.

Besides its two plants in this state, Bird & Son has ten plants outside Massachusetts. In addition to a complete line of roofing and siding materials, the company manufactures corrugated shipping boxes, paper flower pots, tack boxes, beverage cases, and containers for frozen foods. It is one of the largest manufacturers of shoe boxes in the country.

Glassine and greaseproof papers used in the majority of flexible packaging applications including food, confections, retail packaging, and other conversions such as window envelopes, are made in substantial quantities by two western Massachusetts companies. In the town of Monroe Bridge, the Deerfield Glassine Co., Inc. began making these specialty papers in 1926. In Russell, the Westfield River Paper Co., Inc., with branch plants in Lee and West Conshohocken, Pennsylvania, is the second of the two glassine and greaseproof paper manufacturers located in New England.

Segments of the paper industry are also important suppliers to the electronics industry. The Stevens Paper Mills, Inc., founded in 1928, with two plants in Westfield and one in South Hadley Falls, developed the use of kraft pulp in the manufacture of capacitor tissue. As a manufacturer of capacitor tissues and coil-winding papers, it is the only company in the world that manufactures capacitor tissue exclusively.

The Hollingsworth & Vose Company in East Walpole produces electrical insulating, filter, gasket, saturating, and other technical and industrial specialty papers. It is a leader in automotive oil and air filtration, high efficiency air filtration, and electrical insulation.

Most Massachusetts manufacturers of paper from wood do not produce their own wood pulp. They buy sheets of pulp from producers in Maine, Canada, the South, the West Coast, and Scandinavia.

An exception is the plant of the Oxford Paper Company in Lawrence, which makes its own pulp from hardwood logs brought to the mill in trucks from woodlots in Massachusetts, New Hampshire, and Vermont. The plant makes coated papers exclusively which are used primarily in the commercial printing field.

One of the nation's leading paper-converting firms is Dennison Manufacturing Company, with headquarters in Framingham and additional plants in Maynard, Marlboro, and Leominster. Originally established to make jewelry boxes, this company now has eight separate divisions producing a broad range of paper products. It employs about 3,000 persons in Massachusetts.

Dennison is the largest manufacturer of tags, stock gummed labels, and crepe paper in the country, and it is one of the leaders in the production of gummed papers. The Framingham firm produced the first American-made gummed labels a century ago. In 1901, it introduced the first Christmas tags and seals, and thus launched the great gift wrapping industry which has grown over the years to the tremendous business as we know it today. In 1964, this company began to market an office copying machine using Dennison-coated sensitized paper. Sales and service offices for this new division now cover the entire United States and Canada.

Located in Pittsfield is a leading paper converter, the Eaton Paper Corporation, which is the biggest producer of social stationery in the country. Now a subsidiary of Gorham Corporation, this firm rose to its dominant position in the social stationery field through the progressive merchandising ideas of its founder, Arthur W. Eaton.

Until Eaton revolutionized selling methods, the purchase of writing paper was a humdrum experience for the customer. Stores offered only a very limited variety and there was little opportunity to express personal preferences. There was no such thing as packaged stationery, the storekeeper counting out the number of sheets desired from the bulk supply in stock.

Mr. Eaton introduced new, distinctive lines of paper, and he packaged his product in attractive boxes. The boxed stationery was an instant success and led to other innovations, such as the introduction of gay Christmas gift boxes for the holiday trade.

Holyoke is the home of the National Blank Book Company, the nation's second largest manufacturer of loose leaf books. The firm, which employs more than 1,000 persons in its Holyoke plant, makes more than 3,000 different record-keeping products. The company manufactures all types of ring books, sheets, and indexes.

National Blank Book originated "Eye Ease" paper widely used for business and school forms. This is a green tint paper which reflects less light than ordinary white paper, thus eliminating glare.

Also in Holyoke is the American Pad & Paper Company, a leading producer of such items as paper pads, notebooks, and index cards.

Plastic Coating Corporation employs about 500 persons at its plant in Holyoke producing coated papers and films used in reproduction processes by the graphic arts industry and the engineering profession. This company was recently acquired by the Scott Paper Company of Philadelphia.

In Boston, Samuel Ward Mfg. Co. is one of the country's leading producers of social books such as diaries, travel books, scrap books, and photograph albums.

St. Regis Paper Company has three plants in Massachusetts. Its mill in Pepperell produces crepe paper, gummed sealing tape, impregnating papers, and paper for multi-wall shipping bags. At Newton, a division of St. Regis, the Sherman Paper Products Company, makes protective papers for food products, including corrugated dividers for packaged cookies, packages for brown-and-serve rolls, and cups for cupcakes. It also makes plastic tray inserts for candy boxes. In Attleboro, the Sisalkraft Division of St. Regis makes reinforced laminated papers for building construction, industrial packaging and base stock for corner and sealing tapes. Incorporated here in 1920, its rapid growth in the reinforced field has resulted in plant facilities being established in Illinois, California, England, Australia, and New Zealand to service most trading areas not behind the Iron Curtain.

Paralleling Massachusetts' leadership in making fine writing papers is its importance in the production of envelopes.

The use of envelopes to enclose correspondence is of comparatively recent origin. In Colonial days, the address was written on the outside of the paper itself. The paper, folded and bound together with sealing wax, was transmitted without any protective covering.

An early meaning of the word "envelope" was "an earthen fortification." Centuries ago, tribesmen would surround a camp or exposed position with an envelope, and the word thus became associated with the idea of enclosing and protecting.

One of the world's largest producers of envelopes, United States Envelope Company, has its headquarters in Massachusetts, and there are nearly a score of other concerns making envelopes in the Bay State.

United States Envelope Company, with plants in Springfield and Worcester, has 1,200 persons on its Massachusetts payrolls. The company was created in 1898 when 10 companies in the industry, mostly in New England, decided to merge. Today the Springfield-based firm has 12 plants across the country and makes more than 100 standard sizes of business envelopes. It is a major producer of envelopes for the United States Post Office.

The company also makes flexible packaging materials, drinking cups, stationery, school supplies, and a line of text and cover papers.

Other large producers of envelopes in the Bay State include Old Colony Envelope Company in Westfield, Powers Paper Company in Springfield, Sheppard Envelope Company, New England Envelope Mfg. Company and Worcester Envelope Company all of Worcester; Pratt & Austin Co. Inc., Holyoke; Massachusetts Envelope Company, Boston; Ames Safety Envelope Co., Somerville; New England Stationery Company, Boston and Boston Envelope Company in Dedham.

Manufacture of reclaimed fibers, chiefly waste paper, into paperboard is an important part of the paper industry in Massachusetts. Huge quantities of paperboard are supplied to paper converters to be made into boxes, cartons, and containers for packaging a multitude of consumer products.

Continental Can Company, Inc. has two paperboard mills in the state, one in Haverhill and the other in Natick. Sonoco Products Co. also has two, in Holyoke and Lowell.

Bemis Bro. Bag Company employs 300 persons at a plant in Pepperell manufacturing multi-wall shipping sacks. This company also has a subsidiary in Waltham, Packaging Frontier Company, which designs and produces packaging machinery.

In Springfield, Diamond National Corporation has a plant specializing in the production of book matches. It ships some six million books of matches daily, enough for 120 million lights! In Palmer the same company has a plant specializing in molded-pulp egg cartons.

Massachusetts has more than 100 firms which make boxes of one kind or another. Some specialize in folding paperboard boxes like those in which cereal is packaged. Others make set-up boxes such as fancy candy boxes. Still others produce corrugated shipping cartons. Many of the companies do business exclusively with some one industry, such as the makers of shoe boxes, jewelry boxes, or candy boxes.

Container Corporation of America, with plants in Medford and Wakefield, is a large producer of

folding cartons and corrugated containers. Federal Paper Board Company, with plants in Palmer and Medford, is another leading manufacturer of folding paper boxes. Large producers of shoe boxes or "shoe cartons" as they are called in the trade, are Hoague-Sprague Corporation in Lynn and M. B. Claff & Sons in Brockton and Randolph, and Millen Industries Inc. in Lawrence. The Millen firm also has a plant in Northbridge where it produces coated papers for box-making.

Champion Papers recently acquired the Sample-Durick Company in Chicopee, which makes specialty folding cartons for toiletries, photographic equipment, and other products.

There are some 40 producers of corrugated boxes in the Bay State. Allied Container Corporation's big plant in Dedham makes corrugated boxes to package everything from foodstuffs to TV sets to 16-foot folding garage doors. Its 335-foot-long corrugator turns out corrugated board in 8-foot widths at speeds up to 650 feet a minute. The company is a subsidiary of Union Bag-Camp Paper Corp.

Other large producers of corrugated containers include the General Fibre Box Co. Division of Longview Fibre Company in West Springfield, International Paper Company in Somerville, J. &. J. Corrugated Box Corporation in Fall River, Alden Corrugated Container Corp. in New Bedford, Continental Can Company in Cambridge, Rand-Whitney Corporation in Worcester, Owens-Illinois Corp., formerly Charles Dowd Box Co. in Worcester, Hinde & Dauch Division of West Virginia Pulp & Paper Co. in Watertown, New England Container Co. in Chicopee, and Packard Paper Box Co. in Malden.

Ludlow Corporation, whose far-flung operations in many fields are directed from its headquarters in Needham, has two paper converting plants in Massachusetts. These make a variety of paper products for packaging, graphic arts, and instrument recording systems. At Ware, the company produces gummed label papers for printing, heat-seal papers, pressure-sensitive papers, and sensitized recording papers. At Holyoke, a Ludlow subsidiary, Marvellum Company, makes laminated foil-film papers and plastic-coated board for packaging food products. The Holyoke plant also makes industrial papers which are specially treated to prevent rust and corrosion, greaseproof papers, fluorescent printing papers, and greeting card stock.

The original Ludlow Corporation mill, which is located in the town of Ludlow, produces linen and synthetic thread for stitching shoes. The Ludlow business originally centered in the production of jute yarn for carpets. The company is still a leading supplier to the carpet industry and operates a huge jute mill in India. But it has diversified so much into paper, plastics, and rubber that now its jute business accounts for less than half of its total volume of sales. With 14 plants in the United States and four abroad, the company has a total payroll of 13,000. It employs about 500 in Massachusetts.

The oldest independent wallpaper company in the United States is located in Chelsea, the Thomas Strahan Company. Founded in 1886, the Thomas Strahan Company makes a broad line of decorative papers and is especially noted for its Colonial reproductions. Some of New England's best known historic houses are decorated with Strahan reproductions, including the Paul Revere house in Boston, the Lee mansion in Marblehead, and the old Knox mansion in Thomaston, Maine.

The paper on which the Strahan company prints its designs is also a Massachusetts product, made by the Fitchburg Paper Company. The Strahan firm is one of the few wallpaper companies using only pure sulphite paper, containing no ground wood pulp, for its products.

Other wallpaper manufacturers in Massachusetts are Vogue Wall Coverings, Inc. in Fitchburg and Old Stone Mill Corporation in Adams.

Bay State Paper products include such commonly used items as paper bags, paper towels, paper drinking cups, drinking straws, facial tissue, and money wrappers.

The fiber milk container is another item, and a big one! American Can Company turns out more than 5 million half-pint containers in a single week at its plant in Needham. Its production of quart-size milk containers runs close to 2 million a week. International Paper Company in Framingham also produces paper milk cartons.

The paper world in which we live is largely a homemade creation of our own Massachusetts paper industry. A nation destined to grow more in two hundred and fifty years than others had grown in a thousand years, needed paper, tons and tons of it. Far-sighted and ingenious men gauged this need and kept pace with it. They developed better paper, they devised new ways of using paper. Imaginative converters shaped, cut, pressed, coated, and impregnated it to meet thousands of personal, business, and industrial needs.

The paper industry in Massachusetts has nearly 36,000 persons on its payrolls. These people earn almost $200 million in salaries and wages annually. Paper is indeed one of the state's major industries.

The Printing and Publishing Industry

Books, Christmas cards and paperbacks—by the millions

The beginning of the printing industry as a modern art goes back to the invention of movable type by Johannes Gutenberg in Germany about the year 1445. During the next fifty years printing spread rapidly throughout Europe, mainly for the publication of religious works.

It was an American, however, who made possible a giant forward stride in the industry by devising a mechanical typesetter, known as the Linotype. This machine, invented by Ottmar Mergenthaler of Baltimore in 1886, enabled the operator to cast a whole line of type at one time. It revolutionized printing by greatly speeding up the process of setting type, which up to that time had been a laborious task performed by hand.

Gutenberg's 15th century press printed by applying ink to the surface of raised letters and transferring the image directly to the paper through pressure. This method is known as "letterpress" and is still commonly used for many types of work from business cards to newspapers.

Today there are two other major printing processes: offset-lithography and gravure.

Lithography is based on the principle that oil and water do not mix, and in contrast to the raised surface used in letterpress, this process employs a flat surface. Originally this flat surface was a porous stone and later it was found that metal plates could be used. The early craftsmen sketched the design on the stone with a greasy substance and then poured water over the entire surface. The water was absorbed in the blank areas but was repelled in the greasy areas of the design. Then ink was spread over the surface. The ink adhered to the design and was repelled from the blank areas by the water. Thus, when a sheet of paper was pressed against the stone surface, only the design was reproduced.

Offset presses use the same lithographic principle. In the offset process the image is transferred to the paper by means of three cylinders. The inked and watered plate on the first cylinder prints onto a rubber blanket on the second cylinder, which in turn, "offsets" this ink impression to the paper, held by "grippers" against the third cylinder.

The third major printing process, gravure, in contrast to the raised surface of letterpress and the flat surface of offset, uses a depressed surface for transferring the ink. In this process the printing cylinder, carrying the image etched beneath the surface, is inked and, as it rotates, a so-called "doctor blade" wipes off the surface, leaving ink only in the depressions of the etched image. As the cylinder with the paper passes over the etched cylinder under pressure, the ink in the depressions is transferred (by suction) to the paper.

Massachusetts, the birthplace of Benjamin Franklin, often called the patron saint of printing in this country, has many associations with the historical development of the printing industry in America. A printing press was brought to Massachusetts as early as 1638. In that year the Rev. Jose Glover set forth for America with a press he had acquired in England and with Stephen Daye, an English printer whom he had indentured to run it in the New World.

Rev. Mr. Glover died on the voyage but his widow assumed responsibility for setting up the press in Cambridge. Daye and his son Matthew operated this press until 1647. There are still in existence 11 copies of The Bay Psalm Book, which was printed on the press in 1640. The original Stephen Daye press is still in existence. It was later moved from Cambridge and after years of oblivion came to light again in Vermont, where it is now in the museum of the state capital in Montpelier. The well-known Massachusetts printing company, the University Press of Cambridge, Inc., traces its history back to this early Colonial venture.

Printing and publishing and its affiliated groups, the graphic arts, which include engraving and bookbinding, loom large on Massachusetts' industrial and economic horizon. Available figures show that the printing and publishing industry provides well over 40,157 jobs for Bay State workers, has an annual payroll of close to a quarter of a billion dollars with the value added of annual output set at $435,226,000.

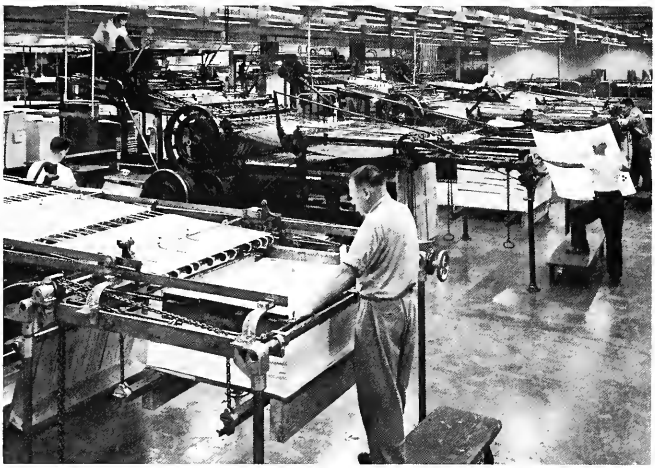
Newspaper publishing accounts for the largest single segment of its employment, but book publishing, especially textbooks, is also a large category. Other important classifications are magazines, periodicals, trade publications, and greeting cards. The area of commercial printing is a giant segment

that includes both large and small printing companies that produce directories, business forms, bank checks, and a host of other printed matter so necessary to the private enterprise system. Calendars, restaurant menus, sheet music, and bridge, baseball, and golf score cards constitute other products of the printing industry in Massachusetts. Add to this printed labels, printed boxes, and instruction pamphlets. The list is endless.

In the golden era in American literature in the middle decades of the 19th century, the Boston firm of Ticknor & Fields had practically a monopoly on publishing the works of the leading writers of the time. The junior partner, James T. Fields, had a special genius for ingratiating himself with the writing fraternity, and his office in the Old Corner Bookstore at Washington and School Streets became a sort of clubhouse where the literary greats of the day assembled. Ticknor & Fields numbered among its authors Henry W. Longfellow, Oliver Wendell Holmes, John Greenleaf Whittier, James Russell Lowell, Nathaniel Hawthorne, Ralph Waldo Emerson, Henry Thoreau, Julia Ward Howe, Thomas Bailey Aldrich, and Harriet Beecher Stowe. Nor was the list confined to Americans as the firm was also the American publisher for such famous English writers as Tennyson, Browning, Thackeray, and Dickens.

After Fields' partner, William D. Ticknor, died in Philadelphia in 1864 while on a trip with the author Nathaniel Hawthorne, Fields

Proofs from the engraver's plate must be carefully checked to assure accurate reproduction from the original drawing.



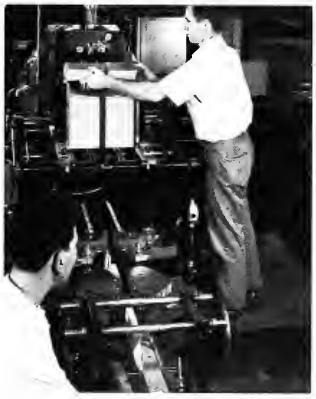
Multi-color printing requires constant checking to assure accurate registration of each color and even flow of ink for best reproduction.

carried the heavy responsibilities of the publishing house alone. In 1870 he sold his interest in the business. His successors encountered financial difficulties, climaxed by the loss of their property in the great Boston fire in 1872. In 1880 the business was taken over by Houghton Mifflin Company.

Massachusetts has played a part, too, in the technical development of the art of printing. Isaac Adams, a native of Rochester, New Hampshire, came to Boston in 1824 and took a job in a machine shop. In 1828 he invented a power press which rapidly superseded hand presses in the printing of books. For more than half a century the Adams power press was the machine preferred for book publishing.

When Adams left Sandwich, New Hampshire, to seek his fortune in Boston, he told friends he would not return until he had money enough "to buy the town." He kept his word. He retired as a millionaire and, returning to New Hampshire, bought many farms and planted them with white pines.

In modern times, an important advance in printing techniques,



A partially completed elementary textbook receives a cover, is pressed, and delivered to a packing line at the rate of 3,600 per hour.

the photographic composition of type, has been pioneered by a Massachusetts firm, Photon, Inc. of Wilmington. Phototypesetting machines, which enable an operator sitting at a keyboard to select any one of several different faces of type and to vary the size from 1/18th of an inch in height to headline type an inch high, early proved their value in setting display advertisements for newspapers. By using a Photon machine, the setting of a full-page advertisement can be accomplished in less than an hour, in contrast to a full day required by conventional methods. More recently, phototypesetters have been developed as the printout system for computers. These new Photon machines can set type at the amazing speed of 500 characters per second.

While Massachusetts has some large companies in both printing and publishing, most of the firms in the industry are small. Of nearly 1,300 Bay State firms listed in the industry in 1963, less than 300 had as many as twenty employees.

Dependent on the printing firms for business are scores of companies providing services to the industry such as typesetting, photoengraving, and electrotyping. The industry also provides a major market for Massachusetts producers of book and printing papers and for companies selling printing inks, bookbinding materials, and photographic equipment.

Training for careers in printing is offered by printing schools in a dozen Massachusetts communities.

Massachusetts has 38 daily newspapers with a total circulation in excess of 2,300,000, and there are about 100 publishers of weekly papers. Total employment on newspapers in the state is nearly 13,000.

The first regular newspaper in the American colonies was the Boston News-Letter, which made its appearance in 1704. In the years immediately preceding the Revolution, two Massachusetts newspapers were conspicuous in promoting the cause of independence. One was the Boston Gazette, which numbered among its contributors such outstanding patriots as John Hancock and Samuel Adams. The other was the Massachusetts Spy, published by Isaiah Thomas.

Boston newspapers are widely circulated in the New England states, and *The Christian Science Monitor*, published in Boston, has world-wide distribution. The *Wall Street Journal* has a regional printing plant in Chicopee Falls.

Of the numerous periodicals published in the Bay State, the best known is the *Atlantic Monthly*, which has its publishing offices in Boston. The magazine is printed in Concord, New Hampshire. The *Atlantic*, established in 1857, was founded by a group which included such well-known writers as James Russell Lowell, Ralph Waldo Emerson, Henry W. Longfellow, and Oliver Wendell Holmes. Lowell was its first editor. The *Atlantic* prides itself on the fact that during its long history it has often been the discoverer and champion of new authors. Politically nonpartisan, the magazine, in its own words "has endeavored to be a liberal and unorthodox exponent of American ideas." Since World War II the *Atlantic's* circulation has more than doubled and now approximates 275,000. Besides readership in every state, it has a circulation of about 20,000 outside of the United States.

Many trade magazines and a number of recreational and scientific magazines are printed in Massachusetts. Cahners Publishing Co. publishes 16 national industrial

magazines and has risen in less than 20 years to its position as the third largest industrial publisher in the country, is headquartered in Boston.

Book publishers nowadays usually do not make the books they publish. They make all arrangements with the author, prepare the copy and illustrations, and distribute the finished product, but the actual printing and binding of the book are turned over to a "book manufacturer." An exception to this rule in Massachusetts is Houghton Mifflin Company of Boston which has a manufacturing division, The Riverside Press in Cambridge.

Books produced in Massachusetts run the entire gamut of publishing, from crossword puzzle books and telephone directories to highly technical college textbooks. Many of the books used in Massachusetts high schools and junior high schools are published by Massachusetts firms and many of them are printed and bound in the Bay State.

Houghton Mifflin Company is an outgrowth of the merging of an old Cambridge printing establishment, The Riverside Press, and the successor firm of the famous old Boston publishing house of Ticknor & Fields.

Henry O. Houghton founded The Riverside Press in an old almshouse in Cambridge in 1852. The old building still houses some of the company's service operations. Today, as the manufacturing division of Houghton Mifflin Company, Riverside's production of books is split about evenly between volumes produced for the parent company and books printed for other leading publishers. For more than a century it has printed and bound the familiar *Merriam-Webster Unabridged Dictionary* and the *Collegiate Dictionary* of G. & C. Merriam Company in Springfield. Houghton Mifflin Company publishes both fiction and nonfiction, juveniles, and textbooks.

Merriam-Webster dictionaries are directly descended from the original great work of Noah Webster. The Merriam brothers, George and Charles, of Brookfield, Massachusetts, began a printing business in 1831 as G. & C. Merriam Company. In 1843, upon the death of Noah Webster, they purchased from his heirs the unbound sheets of his unabridged dictionary with rights to revision. In 1847, they published the first Merriam-Webster dictionary with Noah Webster's son-in-law, Professor Chauncey Goodrich of Yale, as editor-in-chief. The Merriam Company has continued since then as the world's only organization specializing completely in dictionary making.

Little, Brown and Company, one of the oldest Boston publishing houses, brings out on average better than four new books a week. The firm publishes fiction, nonfiction, and children's books. It is Boston's only major publisher of medical books and it also publishes legal volumes. A few years ago, it entered the field of publishing college textbooks and it has a line of quality paperbacks for the college market. Authors whose works have been published by Little, Brown and Company include such celebrities as Louisa May Alcott, Emily Dickinson, E. Phillips Oppenheim, James Hilton, A. J. Cronin, and John P. Marquand. More than a hundred years ago the company took over the published rights of one of the best known literary reference books, John Bartlett's *Familiar Quotations*, and Bartlett himself became a partner in the firm. In 1896, the firm first published Fannie Farmer's *Boston Cooking School Cook Book*, which has had sales exceeding three million copies and continues to be a favorite. Most of Little, Brown's books are printed and bound in New England, many of them in Massachusetts.

Ginn & Company of Boston is one of the largest publishers of textbooks in the country. While primarily publishing books for use in elementary schools and high schools, it has a growing line of college textbooks. In addition to textbooks, the company also publishes school workbooks and tests, charts, and other supplementary material. In the field of audio-visual education, filmstrips are produced in conjunction with the Jam Handy Organization, records and tape recordings are prepared for various textbooks, and RCA recordings are distributed on a national basis. Founded in 1867, Ginn's first book was Craik's *English of Shakespeare*. At first a publisher of classical material, the company later branched into the sciences and in 1870 also published the first graded series of music readers. One of its most famous textbooks is *American History* by David Saville Muzzey. First published in 1911 and periodically updated, this book continues to be the leading textbook on United States history.

A well-known name in the textbook field is that of D. C. Heath & Co. of Boston. Established in 1885 by Daniel C. Heath, who previously had been a partner in the firm of Ginn & Heath, this company publishes textbooks for elementary schools, high schools, and colleges. Many of these books are printed for the Heath firm by Massachusetts book manufacturers. A wholly-owned subsidiary, Heath de Rochemont Corp., produces films used to teach foriegn languages.

Allyn and Bacon, Inc. is another Boston publisher which ranks among the leaders in the textbook field. The firm publishes books for ele-

mentary and high schools and for the colleges. Its Music Division, established only a few years ago, is receiving increasing recognition from music educators. It also has a separate division specializing in the publication of books for Catholic schools. The College Division, started twelve years ago, has already published more than 200 titles. Founded in Boston in 1868, Allyn and Bacon centered its first efforts in the publication of high school Latin and Greek texts. The company's current four-year Latin series is an outgrowth of the highly successful 1907 publication, *First Latin Lessons*, by Smith and Laing. In 1966, Allyn and Bacon will publish the fiftieth edition of Magruder's *American Government*. Almost six million copies of this high school book have been sold since it appeared in 1917, and it continues to be the nation's leading government text.

Addison-Wesley Publishing Company of Reading publishes and distributes textbooks for schools, colleges, and industry, and professional and reference books. The company's current list of titles covers a wide range of scientific, engineering, and business subject areas. Addison-Wesley books are developed and marketed by four operating divisions: School, College, Technical, and International. Although one of the younger textbook publishing firms in Massachusetts, the company is the most rapidly growing publisher in the country, in an industry noted for its growth.

The goal of the overall publishing program at Addison-Wesley is to provide carefully selected books in support of education throughout the world at all grade levels, from kindergarten through graduate school. The company publishes translations of foreign textbooks for American students, exports its English-language textbooks abroad, and arranges for publication of its American textbooks in a number of foreign languages for use abroad. Addison-Wesley's pioneering efforts in exporting were recognized in 1964 when the company was presented with the President's coveted "E" award.

The Colonial Press in Clinton is the largest book manufacturer in New England and one of the biggest in the country. It is the only major company in the industry which produces all three principal types of books: hardbacks, quality paperbacks, and pocketbook paperbacks. It was the first concern in the country to produce the popular pocketbook paperbacks widely sold at newsstands and corner drugstores. Colonial has some of the most modern equipment in the industry. One of its binding machines in a single day has bound as many as 400,000 pocketbook paperbacks. The firm was a pioneer in the use of punched tape to operate typesetting machines. Recently it has simplified the operation of punching tape by employing a computer, which has a dictionary in its "memory" system, to indicate the exact spacing and hyphenation of words necessary to make each line of type fill out to the same prescribed length. The operator of the punch keyboard merely punches in the words and the computer takes care of the spacing and hyphenation.

Colonial, which started as a merger of a Boston printing firm and a Boston bookbinding concern, moved to Clinton in 1931, occupying a former textile plant. The firm has periodically expanded its facilities and recently built a separate additional plant in Clinton to house its offset printing and production of pocketbook lines. In its two Clinton plants the company employs about 1,600 persons.

Besides millions of hardback and paperback books in English, Colonial annually produces carloads of books printed in Spanish, French, Portuguese, Italian, German, and Latin.

A remarkable production feat was scored by the company in the fall of 1964 when it produced and distributed for Popular Library publishers a complete 640-page paperbound book in less than 2½ days. The book contained the complete basic text on the lengthy Warren Commission Report on the assassination of President John F. Kennedy. The text, made available at the White House at 10:30 o'clock Friday morning, was flown to Boston by representatives of the publishers, who edited the copy on the plane. As soon as the copy arrived at the Colonial plant, compositors there started setting the type for the book. The plant operated around the clock and by late Saturday all of the type had been set and printing of the pages began. On Sunday morning binding of the books was started and by Sunday afternoon shipments of the finished product were on their way by air to New York, Washington, and Chicago. The Warren Report was released for publication at 6:30 Sunday evening, and at that hour people in these major cities and in Boston could purchase at newsstands the complete text printed by Colonial. The publishers had hoped to have the book available to the public on Monday, but Colonial had even beaten this optimistic time schedule.

Plimpton Press at Norwood, a division of McCall Corporation, is one of the largest Massachusetts manufacturers of books, largely concentrating on the production of textbooks for leading publishers.

In a single year the plant at Norwood produced nearly 22 million books, and the company's other plant in La Porte, Indiana, turned out another nine million more. Most of the textbooks manufactured by Plimpton are used in the elementary grades and in high schools.

Murray Printing Company in Westford is one of the largest producers of paperbacks in New England, with production largely centered in the educational and scientific fields. The company also does the printing for many books which publishers then have bound in separate bookbinding plants. In all, the firm does business with more than 200 publishers. Besides occupying all of the space in a former textile plant in Westford, this growing firm has had to erect two additional buildings to take care of its increasing business.

Cuneo Press of New England, established in 1951 when the Cuneo Press of Chicago bought Ginn & Company's manufacturing division in Cambridge, produces books for leading textbook manufacturers. Many of the Ginn textbooks are printed there. The company has complete equipment for typesetting, printing, and binding.

Halliday Lithograph Corporation in Hanover prints books for publishers located in all parts of the United States. Its production includes technical books, college textbooks, novels, juveniles, medical, and legal books.

While many book printers have their own binding facilities, the binding of books is often a separate operation performed in specialized shops. Massachusetts has many binderies. In addition to the business they receive from book printers, these shops do a large volume of work for libraries. The biggest employer in this field in the state is the New England Bindery, Inc., Division of H. R. Huntting Company of Chicopee.

Massachusetts firms are also large producers of notebooks, ledgers, loose leaf binders, photo albums, scrapbooks, checkbooks, and stenographic books.

National Blank Book Company in Holyoke employs about 1,000 persons in the production of its line of bound and loose leaf books, indexes, and writing pads, for school, commercial, and social use. It is a leading producer of diaries and snap-a-part business forms.

Other large concerns in this field are Elbe File & Binder Company in Fall River, Springfield Photo Mount Company in Holyoke, and U.S. Ring Binder Corporation in New Bedford.

There are nearly 700 commercial printing establishments in Massachusetts providing employment for more than 11,000 persons. Tiny job shops, printing cards, programs, and stationery, provide a livelihood for printers even in some of the smaller communities of the state. Massachusetts also has some of the largest printing establishments in the country. Some Bay State firms specialize in letterpress printing, some in offset-lithography, and many are equipped to produce either type of printing.

Forbes Lithograph Manufacturing Company in Chelsea produces many of the colorful labels found on cans and bottles for which the housewife looks as she does her shopping. In addition to labels, the Forbes Company also produces decorated folding cartons, box wrappers, and printed film and foil in which many nationally known products are packaged. It also makes a variety of advertising materials, including display posters, banners, catalogs, folders, package inserts, calendars, and greeting cards.

Established during the Civil War to produce multi-colored pictorial labels for bolts of cloth produced by New England textile mills, the Forbes Company was chosen by the United States Government in World War II to print confidential government material important to the outcome of the war. The firm printed secret maps in as many as fifteen different colors and it produced most of the invasion money used by Allied military forces when they stormed into countries which had been occupied by the enemy.

Forbes, now a division of Diamond National Corporation, one of the largest packaging companies in the country, has ten acres of production space in its Chelsea plant with 25 presses for lithographic and gravure printing and many other types of equipment to produce a finished product.

The Brooks Division of Diamond National Corporation in Springfield has the largest plant for multi-color printing in western Massachusetts. It produces lithographed folding boxes, labels, box wraps, greeting cards, and gift wrap paper. Its packaging materials include box wraps for toys and games which are nationally distributed. The firm

Individual folded page sections are sewed together into books by the operators of Smyth Sewing machines.

was established in Boston in 1889 by Joshua L. Brooks. Brooks, who had not yet celebrated his 21st birthday when he started the business, was a believer in the value of advertising. He is said to have spent half of the meager capital at his disposal in the purchase of an imposing sign to hang over the door.

Courier-Citizen Company, whose big plant in Lowell employs more than 1,000 persons, prints all of the telephone directories for all six of the New England states and for southern New Jersey. The company, also a large producer of school workbooks and of snap-out business forms, has other plants in the South, Mid-West, and West Coast.

Woodbury & Company in Worcester specializes in the field of design and in the production of commercial stationery. It produces letterheads for firms in all 50 states. Founded in 1879, the company originally sold industrial plant drawings of New England mills. About 1910, the company developed the technique for reproducing these drawings by engraving on commercial correspondence paper. Today Woodbury is one of the largest establishments in the country devoted exclusively to the design and production of commercial stationery, both engraved and lithographed.

A large printing operation in Middleboro is that of the Winthrop Atkins Company, which is a leading producer of leatherette desk calendars for the specialty advertising trade. The company, which employs about 300 persons, also makes mounts for the photograph trade and it produces a line of paper toys.

Ad-A-Day Company Inc. of Taunton, is another large calendar manufacturer whose advertising desk calendars stand in millions of homes and offices. The founder of this company, Carroll N. Cross, and his wife recently donated their three advertising corporations for educational purposes with the aim of training Massachusetts youth in advertising and graphic arts.

Philip Hano Company, Inc. of Holyoke, established in 1888, is the largest manufacturer of business forms in the East. Its products include snap-a-part forms, register forms, and forms used in electronic computers. The company made a spectacular comeback in 1936 after a disastrous flood along the Connecticut River destroyed all of its paper stock, damaged most of its machinery, and destroyed many of its records. Within two weeks after the disaster, employees were back at work in the floodswept plant. Today, besides expanded facilities at Holyoke providing employment for 350 persons, the company has branch plants in Mt. Olive, Illinois, and Atlanta, Georgia.

Court Square Press, Inc. and Court Square Bank Note, Inc. have one of the largest commercial printing establishments in Boston, employing 450 persons. The former does general printing and lithographic work and was one of the pioneers in color photography. Some of their reproductions are of works by the great master painters. The latter is a large producer of bank checks and has a special equipment for imprinting on the checks magnetic ink characters which make possible the automatic sorting of checks and the processing of them by computers. Besides printing magnetic ink characters on checks it supplies to its own customers, it also does this work for other printers. The firm also prints bonds. Bonds, like checks, have undergone a revolution in recent years. The new type produced by Court Square has much larger and more easily detachable coupons than those of the conventional bonds of the past. About the size of a bank check, each coupon is imprinted with magnetic ink characters for automatic processing.

Buck Printing Co. in Boston, besides being the largest printer of political advertising material in the East, is a leading producer of multi-colored cloth covers for school textbooks. Among many large contracts handled by this company was one to print the nationally-distributed safety booklet, "Welcome to the Highway," for Goodyear Tire & Rubber Co. During World War II the firm produced huge quantities of invasion maps. It has its own bindery and has equipment for three different printing processes: offset lithography, letterpress, and silk screen.

Daniels Printing Company in Boston specializes in fine color printing and produces magazine inserts, catalogs, sales promotional campaign materials, and intricate labels for well-known products.

Relief Printing Corporation in Boston is a leading producer of business calling cards. The firm uses air freight extensively to deliver cards to customers all over the United States. This air service enables the company to compete in speed of delivery with local printers in distant cities.

Scattered around the state are numerous other large printing establishments. Located in Boston are Recording & Statistical Corporation, Semco Industries Inc., formerly Spaulding-Moss Company, Boston Blue Print Company, and R. L. Polk & Company of Massachusetts, Inc. In Waltham are two large producers of business forms: Atlantic Business Forms and The Potter Press. Sullivan Brothers in Lowell and General Offset Printing Company in Springfield also rank among the larger companies.

Massachusetts produces many millions of the six billion greeting cards which Americans buy to send friends and relatives in the holiday seasons and on such occasions as birthdays, wedding anniversaries, and in the event of sickness.

The greeting card business in America had its beginnings in Boston. Louis Prang, a penniless immigrant from Germany, settled in Boston in 1856 and established the business which was later to earn him the title of "Father of the American Christmas Card." The German immigrant at first devoted his talent to the reproduction of oil paintings by a lithographic process of color printing. He perfected this process until he was able to print pictures in as many as seventeen colors with remarkable fidelity to the original oil paintings. By 1860, he was running 45 printing presses in his Boston plant and his pictures were finding a ready sale both in America and England.

A woman is credited with giving Prang the idea of printing Christmas greetings on decorated cards. This was in 1874, and the next year Prang introduced to the American public the Christmas card, which had first appeared in England about thirty years earlier. The response in America was tremendous. Within five years Prang had 300 employees producing five million cards annually.

Today in Massachusetts there are a dozen firms producing Christmas cards and other greeting cards in infinite variety. The custom of sending Christmas cards and valentines has been expanded to Easter, Mother's Day, Father's Day, and other holidays, and beyond that to the extending of greetings on the occasion of most any unusual event in the life of a relative or friend. The growth in the custom has been reflected in the expanding business of greeting card companies in Massachusetts and elsewhere.

Rust Craft Greeting Cards, Inc., one of the five largest manufacturers of greeting cards in the country, has its headquarters and main plant in Dedham. It also has plants in Joliet, Illinois, Detroit, Cincinnati, New York, and Los Angeles, as well as Toronto, Canada, and Leeds, England. Rust Craft's plant in Dedham is one of the largest greeting card plants in the world and employs 1,200 persons. Besides greeting cards, the company produces gift wrappings and a line of decorated paper goods for parties. Rust Craft products are sold in Europe, Asia, Australia, New Zealand, and South Africa, as well as in the United States and Canada. The Dedham firm has its own staff of artists and writers creating new greeting cards and, in addition, it buys ideas from free lancers.

Greeting Service Corporation of New York has a plant in Webster where it prints greeting cards for its Art Guild line of some 6,000 different cards. The Webster plant, established in 1958, at times employs as many as 700 persons.

Sunshine Art Studios Inc., which came to the Bay State from New York a number of years ago, now employs about 250 persons at its plant in Springfield, where it produces a complete line of greeting cards and Christmas novelties.

Metropolitan Greetings, Inc. in Everett, and Octavia-Walton Greeting Cards in Leominster, are other large Massachusetts producers of greeting cards.

Colourpicture Publishers, Inc. in Boston is a leading producer of post cards and other pictorial souvenirs. The firm also has a line of Christmas cards. This Boston concern produces in full color picture post cards depicting historic and scenic attractions in all parts of this country and in some foreign lands. Besides post cards, it prints pictorial folders, miniature albums, picture books, and small guide books. Its annual production runs to well over 100 million pieces.

A nation bursting with growth required tons of printed material to educate and communicate with its people. In an age of great industrial development, Massachusetts printers and publishers contributed greatly to maintaining order in what might have been chaos.

Hot metal type set on the monotype is made up into a mathematical table by a skilled hand compositor. The finished table will appear in a college textbook.

Many manual operations are required in the bindery where printed material is gathered together in its final form. Here cords are being attached to greeting cards.

The Transportation Equipment Industry

On land and sea and in the air — clipper ships to jet engines

The fastest clipper ship the world has ever known; the first automobile built in America; America's first bicycle factory; the finest buggy ever drawn by a horse and one of the first practical pieces of motor-driven fire apparatus in this country—these were the forerunners of the transportation equipment industry in Massachusetts.

The clipper ship was the *Flying Cloud*, designed and built a century ago in East Boston by Donald McKay; the automobile was the Duryea, built in Springfield in 1892; the buggy was a Bailey, made in Amesbury in the late nineteenth century; and the fire apparatus was the Maxim, built in Middleboro in 1914. From them has grown an industry employing 19,061 persons who receive an annual aggregate of $140,647,000 in wages and produce integral aids to transportation every year. This value added is equivalent to $243 million.

Massachusetts still counts 112 firms in the transportation equipment field. Of these nearly half are in ship and boat building. Shipbuilding in the Bay State dates back to 1631, when a vessel commissioned by Governor John Winthrop was launched in Medford. Clipper ships designed by Donald McKay, a native of Nova Scotia, were built in his East Boston yard which opened in 1845. Most famous of these McKay ships was the *Flying Cloud*, which in 1854 sailed from New York, around Cape Horn to San Francisco in 89 days, a sailing record never equaled.

Today in East Boston the Shipbuilding Division of the Bethlehem Steel Corporation maintains a repair yard for merchant and naval ships. This yard might well be termed a ship garage as it has two floating drydocks and other equipment for repairing vessels. During the two World Wars Bethlehem Steel's Shipbuilding Yard at Quincy was a leading producer of fighting ships for Uncle Sam. More recently, in 1961, it produced America's first nuclear-powered missile cruiser, the USS *Long Beach*, and a year later the first nuclear-powered guided missile frigate, the USS *Bainbridge*.

Birth of the Quincy yard was indirectly linked with the development of the telephone. Thomas A. Watson, associate of Dr. Alexander Graham Bell, was the man to whom the inventor sent the world's first telephonic message: "Mr. Watson, come here, I want you." With the money Watson realized from his investment in the telephone, he largely financed the Fore River Engine Company, which later became the Fore River Shipbuilding Company. This Quincy yard received its first Naval contract soon after the battleship *Maine* was blown up in Havana Harbor in 1898. During the Spanish-American War which followed, the yard was commissioned to build two torpedo boat destroyers. In subsequent years it built several cruisers and battleships. Bethlehem Steel Corporation acquired the yard in 1913 and it eventually became known as the Quincy Yard of the Shipbuilding Division of Bethlehem.

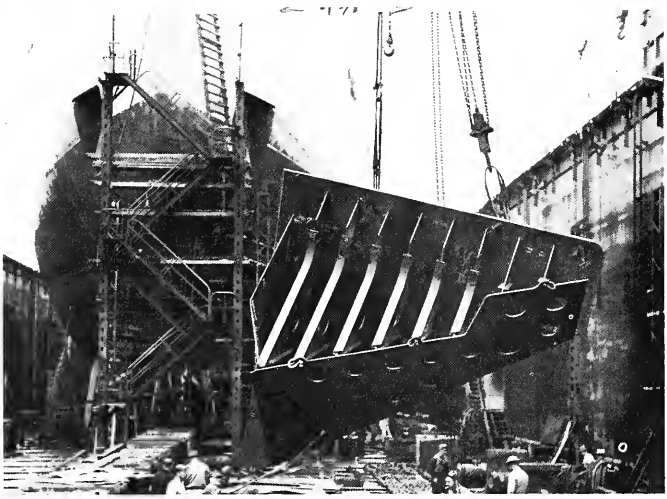
Almost immediately World War I began, and during that conflict the yard did a tremendous job of turning out fighting ships. Then, during World War II, it added to its laurels producing and launching 19 cruisers, 18 destroyer escorts, 46 LST's, and five aircraft carriers. At peak production the yard employed 32,000. In addition, Bethlehem operated a new, 16-way yard in nearby Hingham to meet the pressing wartime need for more naval vessels. In 39 months, with an employment of 25,500, this yard turned out 227 destroyer escorts, LCI's, and LST's.

Following the war, the Quincy yard built many naval vessels, oil tankers, freighters, and special purpose ships including two 30,000-ton passenger vessels. These were the SS *Constitution* and the SS *Independence*, both of which today ply the ocean lanes to Mediterranean ports under the flag of the American Export Lines. With shipbuilding capacity throughout the world greater than the demand for new ships, competition finally forced the Quincy yard out of its regular business of building naval and commercial surface vessels. In late 1963 after fifty years of Bethlehem operation, the yard was sold to the General Dynamics Corporation to become an adjunct of the company's Electric Boat Division. This division is headquartered in Groton, Connecticut, and is the nation's largest private builder of submarines. With the change in management, this Massachusetts shipyard, famed in the annals of American shipbuilding, has taken a renewed lease on life. Its employment has climbed to a total of 6,000 and it has contracts to build two nuclear

attack submarines, two ammunition ships, and a submarine tender for the Navy and three Apollo instrumentation ships for the Space Administration. In addition, it is engaged in lengthening two attack submarines.

In the shipbuilding and ship repairing industry are a handful of small but well-known firms located on the seacoast from Gloucester to New Bedford. Among the larger are two East Boston companies, Bromfield Corporation and the General Ship and Engine Works. The latter company, located on the very site where Donald McKay's *Flying Cloud* was built, has also constructed some 13 vessels for private industry and nine vessels for the United States Government. Linking the past with the present, this shipyard uses one of Donald McKay's old axes, retrieved from the mud, to cut the final line in launching its vessels. At Fairhaven, the Hathaway Machinery Company manufactures commercial fishing deck machinery and oceanographic equipment and machinery, as well as general marine equipment. A substantial number of manufacturers are in the small boat building and repair business. Their "fleets" are fabricated from wood, fiberglas, aluminum, and in some types a combination of two or all three of these materials. Sailboats, rowboats, outboards, inboards, dinghies, small cruisers, sports fishermen, and small commercial fishing and lobster boats are produced here, with most of the companies having a relatively small work force. Building small boats is not a big business in Massachusetts, as far as employment is concerned.

Many hundreds of massive naval and passenger vessels, freighters and oil tankers have been constructed in the Quincy shipyards.



A heavy hull section for a Navy icebreaker is moved into place in a floating drydock.

One of the companies building boats in the Bay State is The Fisher-Pierce Co., Inc. of Rockland. This firm makes sled-type fiberglass outboard boats trademarked "Boston Whaler." They are built of a fiberglass-foam-fiberglass sandwich construction with unusual buoyancy and strength, which is responsible for their selection not only by sportsmen, but by Government Patrol Agencies and the Coast Guard.

In Amesbury, the Henschel Corporation is a nationally-known manufacturer of an extensive line of marine items including ships order control equipment, audible signal equipment, control and alarm panels and fire alarm systems.

The Cape Cod Shipbuilding Company, founded in 1899 at Wareham, is a leading builder of small sailboats. It was one of the pioneers in developing fiberglass construction. It now uses fiberglass exclusively in its 36 models of sailboats, ranging in size from 9-foot to 44-foot boats. In 1941 the company acquired the small boat department of George Lawley & Sons, Inc. and in 1947 it obtained exclusive rights to manufacture the internationally known Herreshoff "Bull's-Eye" and other Herreshoff boats. Cape Cod Shipbuilding's subsidiary, Zephyr Products, Inc., is the world's largest producer of aluminum spars for sailboats.

The O'Day Corporation in Fall River lays claim to the title of "world's largest manufacturer of fiberglass sailboats, 8 to 23 feet long." Its founder, George O'Day, at the age of twelve started racing sailboats in Marblehead. He has been an enthusiastic racer ever since and has won countless trophies. In 1960 he won a gold medal in sailboat competition in the Olympic Games.

Oddly enough, while O'Day's own interest in sailing is in competitive events, his business is built on an entirely different concept of sailing. As a manufacturer, O'Day broke with the custom of building sailboats of traditional classes for competition and designed his boats to provide enjoyment on the water for the casual skipper and his family. The idea of "family sailboat living" caught on and the O'Day Corporation, which started building boats only a few years ago, has had a remarkable growth in this short time. O'Day Corporation's line of fiberglass sailboats, known familiarly as "Day Sailers," ranges in size from the "Seven-Eleven," which is just under 8 feet in length, to the 26-foot "Outlaw."

Several companies produce specialty parts for marine use. These companies include Paragon Gear Works of Taunton, nationally known manufacturers of marine transmissions, and Merriman Brothers, Inc. of Boston, a wholly-owned subsidiary of UTD Corporation of Athol. Merriman is one of the oldest names in marine hardware, producing a complete line of high quality yacht fittings. The company is relocating in Hingham, where it will be housed in a new, modern one-story plant containing 180,000 square feet of floor space.

What has been called "the first commercial railroad in the United States" was constructed in Quincy in 1826. This railroad, which used horses for power, ran three miles from a granite quarry to the Neponset River. Over it were transported the big blocks of granite used to build Bunker Hill Monument in Charlestown.

In the early days of railroading, Massachusetts firms built steam locomotives. The Taunton Locomotive Manufacturing Company in Taunton built the first railroad engine to operate west of the Mississippi. Averill & Company in Springfield was turning out ten locomotives a month by 1852.

The first railroad sleeping car ever made in the United States was built for George Pullman by T. W. Wason & Company in Springfield in 1850. This firm manufactured both passenger and freight cars for the railroads.

The Osgood Bradley Car Company in Worcester, later acquired by the Pullman Standard Car Manufacturing Company, was at one time the second largest manufacturer of railroad passenger cars in the country. It also made cars for street railways. With the decline in railroad commuter service in recent years, demand for new railroad cars decreased to the point where the Worcester plant was forced to close. Today there are relatively few Massachusetts firms furnishing railway equipment.

To Charles E. and J. Frank Duryea of Springfield goes the credit for America's first successful gasoline-powered automobile. In 1892, they tested on the road this automobile in their home city, and in 1893 the car was in operation. In 1895, the brothers established the first American company to make gasoline cars, also in Springfield. By winning a pair of pioneer auto races the Duryea brothers focused world attention on their Springfield plant. In 1896, two Duryea cars participated in a run from London to Brighton, England, which marked the first appearance of American motor vehicles in Europe.

The Duryea Motor Wagon Company, as this first automobile factory was called, had only a short life. In 1902, the J. Stevens Arms & Tool Company began the manufacture of a two-cylinder car, called the Stevens-Duryea, one of the better known makes in the early days of automobiling, designed by

J. Frank Duryea. This car inspired others to try, and no less than 100 makes of automobiles were produced in Massachusetts by companies which have long since gone out of business or concentrated on other lines.

Of the many automobiles which were propelled by steam and which were produced in the early part of the century, the most successful was the one made in Massachusetts by twin brothers, Francis E. and Freeland O. Stanley. The Stanley brothers made their first steamer in 1897 and in 1902 they organized the Stanley Motor Carriage Co. Their cars were remarkably simple and efficient.

The hill-climbing ability of steamers was dramatically demonstrated by Francis Stanley when he drove one of his cars up Mt. Washington in 28 minutes, at a time when the best gasoline cars required nearly two hours for this ascent.

In their heyday steamers were the fastest cars on the road, but their speed ultimately proved to be their undoing. In the 1906 speed trials at Ormond Beach, Florida, a Stanley steamer attained a speed of 128 miles an hour, double that of its nearest gasoline rival, but a bump in the road caused the driver to lose control of it and it crashed disastrously. This incident made the public wary of steamers on the theory that they were just too fast to stay on the road.

The building in Watertown in which the Stanley brothers produced their cars is still standing and is now used by Bachrach Inc., portrait photographers, as a photo finishing plant. By an odd coincidence, Francis Stanley himself was a leading portrait photographer early in his career and before he and his brother became interested in automobiles they operated a successful photographic supply business.

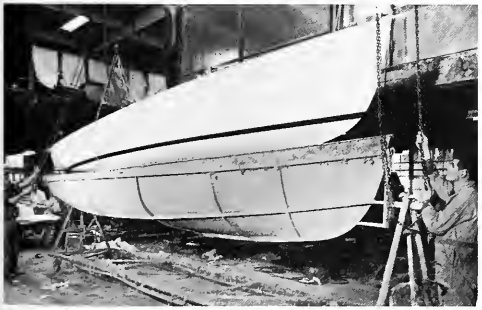
New England's only automobile assembly facility is the huge General Motors plant covering a 178-acre site in Framingham. It opened in 1948 as a Buick-Pontiac-Oldsmobile assembly plant. Production was switched a few years ago to the complete assembly of Chevrolet cars through the establishment of the Chevrolet and Fisher Body Divisions. Fisher Body assembles the body of the car, while the chassis and final assembly are the responsibility of the Chevrolet branch. Currently, with a work force of more than 2,700, the plant is producing over 105,000 cars a year, the majority of which go to supply the New England market.

The economic impact on the Massachusetts economy of this large automobile plant can be measured, at least in part, not only by the total number of jobs provided but by the dollars expended for goods and services. The General Motors Framingham payroll topped $18 million in 1964, and during this same year G.M.'s plants spent more than $76.2 million for goods and services from 864 Massachusetts firms.

General Motors also operates a training center in Dedham for dealer and fleet-owner personnel, as well as the AC Spark Plug Division research and development center on Route 128 in Wakefield.

In Middleboro is the only early auto industry still in business. This is the Maxim Motor Company of Middleboro, builders of fire-fighting apparatus. For Carlton W. Maxim, owner of a Middleboro mill which produced high quality inside wood finish for builders, his hobbies became his vocation. Maxim, a natural mechanic, early developed an interest in the horseless carriages which were beginning to appear at the turn of the century. He was also interested in fire fighting. It is not surprising that eventually he wound up manufacturing motor fire apparatus.

Maxim had the first automobile in Middleboro, a 1901 steamer. In the early days of motoring his barn became a rendez-vous for early automobile enthusiasts in the town.



The development of fiberglass for small boat construction opened a complete new field for boat builders.

Today's fire fighters are prepared for every type of fire with compact, mobile equipment.

Maxim had a knack with motors, and they turned to him to cure the ailments of their balky vehicles. Eventually Maxim established a garage in an abandoned street car barn and went into the auto business in a big way. He built his first piece of fire apparatus in 1914. It was a four-cylinder, chain drive hose wagon for the Middleboro Fire Department.

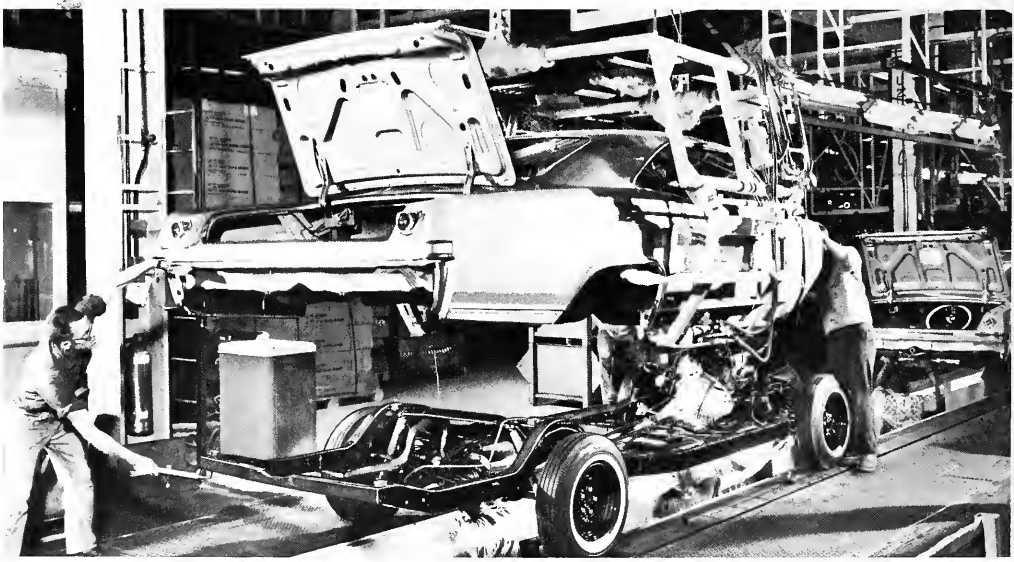
Today Maxim Motor Company custom builds pumpers and ladder trucks for fire departments in many Eastern communities. Its sales extend even to the West Coast. Deliveries, incidentally, are made by driving the new apparatus over the road to the purchaser. This applies to distant deliveries, too. A Maxim truck was recently delivered over the road to Seattle.

Besides conventional fire-fighting equipment, Maxim also makes special-purpose equipment, such as airport fire trucks, forest fire trucks, and apparatus equipped to combat fires originating in hazardous industries. The company also maintains a 24-hour repair service to help communities get damaged vehicles back into service speedily.

The Bailey Company, Inc. of Amesbury, whose history dates back to 1856, was originally engaged in the business of making carriages and sleighs. Toward the close of the nineteenth century, the company produced a free-running road buggy. This buggy had a narrow box body and it shared its name with numerous other makes. All were known as piano boxes or Bailey buggies. However, there was only one real Bailey, the "Whalebone Road Wagon," and nothing made in America or abroad could approach it for its qualities of design, lightness, and strength. The production technique used in assembling this wagon was an early, if not the first, example of interchangeable parts manufacture, later called "mass production."

Widespread use of the automobile drove the buggy off the road, and the Bailey Company switched briefly to auto manufacture, an electric, just before World War I. But after the war, Col. Edwin W. M. Bailey and his sons saw an opportunity to specialize in the manufacture of channels for the glass windows in sedans. These were a development from the early touring cars, but the closed bodies were a nuisance because the windows rattled and cracked when cars were driven over rough roads. Today the Bailey Company supplies leading car manufacturers with weatherstrips and glass channels.

Amesbury, incidentally, was an early center of automotive manufacture. The town had been a leading producer of carriages and had a labor pool of skilled craftsmen in that industry. The early auto bodies were built largely of wood, and it was a natural switch from carriages to auto bodies. The



Dramatic moment when body meets chassis as workmen guide lowering body onto locating pins.

Biddle & Smart Company in Amesbury built the bodies for Hudson and Essex cars until the early 1930's.

Several Massachusetts concerns make motor vehicle parts for leading auto and truck manufacturers, supplying such items as diesel fuel injection systems, electrical equipment, and body components. Others make such automobile accessories as seat covers, convertible tops, seat belts, air conditioning units, spotlights, and license plate frames. Several other companies produce automotive wrenches, auto body repair tools, armatures, and other components. Some companies specialize in the rebuilding of automotive parts such as engines, carburetors, and fuel pumps.

The American Bosch Division, American Bosch Arma Corporation, in Springfield is the largest independent manufacturer of diesel fuel injection systems in the country. It supplies injection systems to the leading truck and tractor manufacturers. American Bosch also produces ignition systems for stationary gasoline engines of the type used to operate pumps in the oil fields and similar industrial functions, and carburetion equipment for LP (liquid propane) and natural gas-powered engines. It also builds compact 38 horsepower electric motors, about half the size of a typewriter, which provide the propulsion for Navy torpedoes. In addition, it makes hydraulic systems to operate the doors of missile silos, start engines, and operate various types of equipment.

Wico Division of Globe-Union Inc. in West Springfield, a leading manufacturer of ignition systems for gasoline engines, was founded in 1897 by Thomas Witherbee, the inventor of the first portable storage battery. Since storage batteries in those days were called "igniters," the firm was incorporated under the name Witherbee Igniter Co. This name was changed in 1920 to Wico Electric Co. The firm merged in 1956 with Globe-Union Inc. of Milwaukee.

Wico makes magnetos, alternators, small type batteries, tachometers, speedometers, and transistor ignition systems. Its products are used on gasoline-powered tractors, outboard motors, lawn mowers, motor scooters, chain saws, and heavy construction and automotive equipment.

R. E. Phelon Co., Inc., East Longmeadow, produces magnetos, permanent magnet generators, and ignition parts.

Cole-Hersee Company of Boston supplies leading automobile manufacturers with a wide variety of switches used in the electrical systems of autos: switches to turn on the ignition for starting, to start the defroster blower, to light the instrument panel, to blow the horn, to raise or lower the tailgate glass, and many others. The company also supplies auto manufacturers with lamp sockets. The Joseph Pollak Corporation of Boston, established in 1909, is a large producer of automotive and marine switches, connectors, hose clamps, and relays. In Watertown, Ark-Les Switch Corporation manufactures both switches and terminals. Nu-Era-Gear Mfg. Co. in New Bedford manufactures auto transmission gears. In Boston, Arrow Armatures Company produces automotive generators and starters.

United-Carr Incorporated in Cambridge sells its fasteners to all the leading automobile manufacturers. They are used to attach the exterior trim of the car, to hold tubing and wire in place, and to attach upholstery trim. The company also makes switches and light sockets for the auto industry.

Standard-Thomson Corp. of Waltham is an important supplier to both the automobile and aircraft industries. It makes thermostats for the cooling systems of cars and trucks, and it is a leading supplier of rear view mirrors. Its aircraft products, including heat exchangers, valves, and bellows, have wide acceptance in the industry. Metal bellows made by the company are used in many industrial instruments.

Weymouth Art Leather Company of Braintree supplies all of the "Major Four" automobile manufacturers with vinyl coated fabrics, which are used for upholstery, door panels, and padded dashes. The company's coated fabrics are also used for upholstered furniture, for women's boots, and for men's slippers.

Several firms make replacement storage batteries for automobiles in the Bay State, including Gould-National Batteries in Marlboro, Hartford Battery Company in Waltham, and Atlantic Battery Company in Watertown. The Atlantic company also makes storage batteries for industrial trucks. At Salem the Surrette Storage Battery Co. manufactures marine batteries for fishing craft and other vessels, producing single units weighing up to 400 pounds. This firm also makes batteries for locomotives, trucks, buses and golf carts.

There are about twenty companies in Massachusetts making truck bodies. Most of these companies are small, employing less than fifty workers, but they make all types of bodies for commercial vehicles. Some specialize in refrigerator truck bodies, and one makes bookmobiles. One of the largest, the James Kiley Company of Somerville, concentrates on the manufacture of bodies for the trucks used by public utility companies, producing specially designed equip-

ment for telephone, electric, gas, and water service.

Although no longer manufacturing in the state, Ford Motor Company maintains an extensive automotive parts depot in Natick. Chrysler Corporation also operates a similar depot in Natick.

The importance of the American automobile industry to the Massachusetts industrial economy today cannot be measured alone by the short historical descriptions which the limited space of this text permits. For example, it has been estimated that 20 per cent, or one in five, of all the industrial jobs in the city of Worcester are dependent, directly or indirectly, on the automotive industry.

Although the "Indian" motorcycle was once built in Springfield, the only two-wheeler now made in Massachusetts is the "Columbia" bicycle manufactured by Columbia Manufacturing Company, Inc. of Westfield. The idea that formulated this company began with Colonel Albert A. Pope, who, having served through the Civil War, was searching for a product with which to found a business. He found just what he wanted at the Philadelphia Centennial Exposition in 1876 where he was fascinated by a display of imported high wheel bicycles. A year later in Boston, he built the first model "Columbia" and in 1878 started producing them commercially, the first such production in the country. All this took place after Pope made a tour of Europe to study manufacturing and to learn public reaction to the new-fangled machine. In 1879, George A. Long of Northfield built a 2-cylinder V-type steam engine, and the following year he completed the framework and running parts of a tricycle in Albert Pope's bicycle factory in Hartford. This was known as the Long steam tricycle.

Riders of the early "high wheelers" found themselves in danger of taking a toss over the four-foot front wheel. Although the first "Columbia" was a high wheeler, Colonel Pope quickly saw that this built-in fault must be corrected. He switched to producing the so-called safety, both wheels the same size, a forerunner of our modern bike.

Among Columbia firsts are: the chainless bike, propelled by shaft and gears, the diamond frame, the spring fork, the twinbar frame, the tandem, the pneumatic tires, the coaster brake, and the cushion fork. Although many of these improvements were undreamed of in Colonel Pope's day, they came about because of the similar questing minds of the men who followed him in the management of the company.

Colonel Pope's first factory in Westfield was the empty plant of the Lozier Automobile Company. Early in this century the business was moved to Westfield, where it has since been one of that community's principal employers. This is a fitting reward for the local subscription which established it there. Perhaps in acknowledgment, another bicycle, the Westfield, was added to the line.

Colonel Pope is known as the founder of the American Bicycle Industry and also as the Father of Good Roads, for no one did as much as he to promote them. He arranged for a special exhibition section of hard surface road near Boston, making use of the invention of a Scotsman named MacAdam. This name is now a common word for modern highways. The firm was once known as the Westfield Manufacturing Company and from 1933 to 1960 was a subsidiary of the Torrington Company. Columbia is now an independent corporation and employs between 400 and 500, a figure which jumps to 700 at peak times.

There are five million bikes sold yearly in America today. Although this figure is boosted by imports from England and 18 other lands, Columbia contributes a large share, both with its own name wheel and the bicycles it makes for other firms. Columbia makes bicycles for some of the largest national chains in the automotive and general merchandising fields. Columbia had its biggest year in 1964, when its output topped all previous years in its 88-year history.

Persons-Majestic Mfg. Company of Worcester also produces bicycle parts and accessories.

One section of the transportation industry in Massachusetts that involves a relatively small number of companies is the production of aircraft engines and aircraft equipment. The most important Bay State company in this field is the General Electric Company, whose Small Aircraft Engine Department in Lynn employs about 5,000 in the manufacture of small military aircraft engines. General Electric also makes parts for large jet engines at its Everett plant.

Titeflex, a Division of Atlas Corporation in Springfield, which pioneered in the development of flexible metal hose, manufactures a variety of highly-specialized products for the transmission of fluid and electrical energy which are used in aviation. Its products range from hose and tube assemblies, special fittings and fluid couplings, to complete wiring harnesses and electrical connectors.

Helio Aircraft Corporation, which makes a fixed wing STOL aircraft which might be described as halfway between a helicopter and a conventional plane, maintains research and development facilities at Hanscom Field in Bedford. It also manufactures some parts there for its assembly plant in Pittsburgh, Kansas.

In Peabody, the Lawson Manufacturing Company, a division of Amtel, Inc. is the largest production job shop east of the Mississippi River. It employs 500 people, on two work shifts. This company, formerly operating under the name of Lawson Machine & Tool Company, has no product, but the bulk of its work is the manufacture of precision aircraft engine, missile and rocket engine parts, accessories and assemblies for Pratt & Whitney Aircraft, Division of United Aircraft Corporation, East Hartford, Connecticut.

A wide variety of machine tools, some tape controlled, are used to machine the more than 3,700 different parts from aluminum, stainless steel, titanium, magnesium, and other exotic metals. These parts are used on jet engines for both commercial and military aircraft, propulsion and control systems on the upper stages of the Saturn rocket, and also on missiles.

Components and assemblies for the aircraft industry are manufactured by several other Massachusetts firms including Babco Products, Inc., Danvers, components for jets and missiles; Androform Industries, Inc., North Dighton, special aircraft panels of titanium; B & E Tool Company, Southwick; Kelox Industries, Inc., Norwood; Moulton Products Company, Georgetown; Berkshire Tool Co., Inc., Westfield; Eastern Industries Division, Laboratory for Electronics, Inc., Newton; Walbar Machine Products Inc., Peabody, machined parts for jet engines; and Experimental Tool Works, Inc., West Springfield. The Jamesbury Corporation of Worcester is a primary supplier of valves used in the loading and unloading of railroad tank cars. In addition, as the trend towards shipping materials in liquid form has expanded, the company also produces valves used in tank trucks, barges, and ocean-going tankers. Hansen Engineering Machinery Co., Inc. of Lynn manufactures precision machined components and assemblies for the aircraft, electronics, and missile industries. This company also operates one of the largest Non-Destructive Testing Laboratories on the North Shore, testing aircraft components for General Electric Co., Lycoming Division Avco Corporation, Pratt & Whitney, United Shoe Machinery Corporation, and numerous companies involved in aircraft and missile production.

To early settlers, one method of transportation was important: ships. Our economy was dependent upon our ship architects and their ability to build fast, sturdy vessels for trade on the Seven Seas. No other section of the country ever matched production abilities then, and today the vessels we produce for trade and for pleasure still bear the mark of generations of knowledge.

By comparison, travel by land was brutal discomfort until rails were laid and Massachusetts manufacturers began the building of locomotives, coaches, Pullman cars, and luxurious dining cars. Horseless carriages, instead of spelling doom for hundreds of carriage manufacturers, increased their employment and prosperity as they changed to auto bodies.

The automobile industry and later the airplane industry turned to Massachusetts engineering ingenuity for help in its development. Today a new space age again looks toward the same skills.

Bicycles move along final assembly line.

Diesel fuel injection pumps at start of 40-foot moving assembly line.

The Utilities Industry

Life lines of today's industrial world

In the early days of our industrial history a prolonged drought was disastrous for manufacturing enterprises. Mills were dependent on water power to turn grinding stones, lathes, and looms. Today any stoppage of electric current or gas to factories can be equally disastrous. Manufacturers depend on public utilities to provide the energy which runs their machinery, provides heat and refrigeration for industrial processes, and illuminates their plants. The office staff depends on power to run electric typewriters, adding machines, and computers.

Furthermore, modern business depends on the telephone company to provide speedy communications with customers, with distributors, with salesmen, and with suppliers.

The Massachusetts electric, gas, and telephone utilities are vital to industrial production. The achievements, and the plans for the future of these utilities are described under separate headings in this chapter.

THE ELECTRIC UTILITY INDUSTRY

Flip a switch and city streets shimmer with light. Push a button and an elevator moves swiftly upward. Turn a dial and a home is heated, food cooked, clothes washed and dried, or a giant machine is set into operation. Such is the magic of electricity—the product manufactured, transported and distributed by the electric utilities of Massachusetts.

What is this invisible energy that powerfully and efficiently performs so many tasks? Although a scientific answer would describe a "flow of electrons" moving from one atom to another, the best description is an analogy: Electricity is a powerful surge of energy racing under pressure along a path with few obstacles to impede its passage.

How is it created? A magnet, rapidly spun inside a wire coil, will create a current of electricity within the coil. The bigger the magnet, the more wire in the coil, and the faster the revolutions, the more electricity.

The trick is to spin the magnet. By burning coal, oil or natural gas, water is heated and turned to steam. When expanding steam pushes against the blades of a turbine, the revolving turbine spins the magnet inside a generator.

A second way to produce this heat is to split the atom. In Massachusetts, the Yankee Atomic Electric Co., located in the western part of Massachusetts in the small town of Rowe, produces electricity by this method. Built at a cost of $43 million, their first nuclear power plant in New England has produced more electric power than any other nuclear plant in the world!

A third way to produce heat is to drive a turbine by the weight of water falling over a dam. Both the Connecticut and Deerfield Rivers are used to create electric energy by this method for the people of Massachusetts.

The most common means of manufacturing electricity in the Commonwealth is through conversion of fossil fuel energy, first into steam energy and finally into electric energy.

Flowing from the generators, electricity is given increased pressure (voltage) by transformers and sent out over high voltage transmission lines. The voltage of electricity is decreased by transformers in substations located near the point of ultimate use. Distribution lines run from the substation along the streets. Finally, a third transformer, high on a street pole, will reduce the voltage still further before power is sent into the homes, offices, farms, and factories where it is to be consumed.

Who discovered this most flexible of all energy sources? It is difficult to say. The Greek philosopher Thales knew about static electricity in 600 B.C., but he was not the first. The Chinese had experimented with the magnet many centuries earlier.

Benjamin Franklin drew energy from the sky down the string of a kite. Alessandro Volta, an Italian, worked with electricity, as did Andre Marie Ampere of France. An Englishman, Sir Humphrey Davy, forced electricity to jump between two pieces of carbon to create a crude arc light, and the scientist-inventor, Michael Faraday, proved that if electricity can make a magnet, a magnet can make electricity—the fundamental principle behind power generation.

However, American genius Thomas A. Edison, the Wizard of Menlo Park, harnessed electric energy, invented new uses for it, and formed some of the first electric utilities under the free enterprise system. Motivated by the idea that electricity could be produced in large quantities and put to work, he borrowed money to back his theory and

produced and sold electric energy. From this minute 1882 beginning comes the vast $54 billion dollar industry of today.

In Massachusetts the first Edison affiliated electric utility was formed in Brockton in 1883, but small "arc lighting" companies were in existence in larger cities. Street railways soon abandoned horsedrawn cars to convert to electricity, while small water-powered factories found electric energy more efficient to turn lathes and wheels.

From this modest beginning the present thirteen investor-owned electric companies of Massachusetts built generating stations, transmission and distribution lines, switching equipment and hundreds of other facilities valued at over 1½ billion dollars.

Last year these utilities sold over 14 billion kilowatt hours of electricity or enough to light a thousand 100 watt bulbs for 16,000 years. They use more than 3 million tons of coal, pay over 40 million dollars in federal and state taxes, provide another 48 million dollars for local taxes to cities and towns, and employ about 12 thousand Massachusetts people in jobs ranging from research to meter reading.

Since 1950, the electric companies in the Commonwealth have spent over 1 billion dollars on new construction; and, during the next fifteen years, they will contribute to the investment of some 3½ billion dollars in new and replacement electric facilities for all of New England.

What are some of these companies serving the state and its citizens?

Years of training and experience are required to enable telephone workmen to "read" the thousands of wires and connections required in complicated telephone systems.

Pushbutton consoles help telephone operators provide faster personal service on long distance person-to-person calls and calls from coin telephones.

Massachusetts Electric Co. (622,000 customers), Boston Edison Co. (495,000), Western Massachusetts Electric Co. (144,000), Brockton Edison (72,000), Cape & Vineyard Electric Co. (51,000), Fall River Electric Light Co. (45,000), Cambridge Electric Light Co. (38,000), and Plymouth County Electric Co. (31,000) are among the largest.

Each utility is interconnected with its neighbor enabling the industry to exchange power so that only the most efficient, low cost plants are producing electricity to meet the constant or "base load" demand. At times of increased demand or when lights and heat and TV and machinery are operating at once, the older, less efficient plants of all companies may be called into service together with hydro-electric facilities to meet the sudden or "peak" demand. So extensive are the interconnected power expressways of Massachusetts that a sudden loss of generating facilities anywhere in the Commonwealth instantaneously brings into play the vast reserve capacity of other New England states and even from places as far away as Chicago. Maintaining this constant access to outside power sources is a major achievement of this complex industry.

In many respects the electric utility business of Massachusetts is like other large industries. It manufactures a product, promotes its sale to the general public, and constantly attempts to lower the cost of its service. One additional factor is important: utilities serve only an exclusive area through charters granted to them by the Commonwealth. It would be a vast waste of time and money for several companies to build lines and other facilities in the same area.

While utilities do compete for consumer dollars which might otherwise go to buy items like cars, furniture or other energy sources, they do not compete among themselves. To offset this lack of direct competition, they are regulated by the Massachusetts Department of Public Utilities which controls the rates charged for electricity in addition to other aspects of the utility business. Investor dollars, efficient management, skilled labor and wise government regulation join together to bring the magic of electricity to the homes and industries of Massachusetts.

THE GAS UTILITY INDUSTRY

The history of the gas utility industry in Massachusetts is a story of challenge and change. It is also a story of continuous dedication in supplying the Commonwealth's citizens with vital and important fuel services. But this dynamic industry which makes countless contributions to the comfort and convenience of Massachusetts people every day is very different from that which a small group of prominent Bostonians founded in the Town of Boston over 140 years ago.

A look into history shows that man first sought to manufacture gas for a better source of light. It was a 17th century Belgian alchemist named John Baptist Von Helmont who discovered the first method of manufacturing gas. By heating coal in a vessel and holding a candle over the open end, he found that a flame was produced at the opening. The "wild thing," as he called it, was not put to practical use for nearly 200 years.

Gas was first successfully applied in England for the lighting of Westminster Bridge in 1813. Word spread across the ocean and the first company to operate in this country started in Baltimore, Maryland, in 1816. Six years later, a group of Boston businessmen founded the Boston Gas Light Company for the purpose of providing better street lighting.

The Company's first ventures were experimental and attempts to provide illumination by gas were undertaken in Bacon's Apothecary Shop on Court Street, in a boot shop owned by Daniel Darby in the home of John Raulstone. Later, a theatre, some individual houses, and some crude lamps of Tremont Street were supplied with gas for lighting. In 1828, the first gas manufacturing plant was built on the site of Boston's old North Station. On January 1, 1829, the first successful lighting of the City's streets took place in Dock Square. It was the subject of a public celebration led by Mayor Harrison Gray Otis and the City Aldermen. The new and novel illumination marked the beginning of the gas light business in Massachusetts.

As knowledge improved and equipment was refined, gas moved into the home and by 1855 gas had replaced whale oil lamps and candles as the chief means of residential lighting. By the latter half of the 1800's, the gas lighting industry was flourishing in Massachusetts and across the nation.

Gas was first sold not by the volume used but on a fixed charge for the number of burners installed or the size of the pipe used to deliver the product into the consumer's premises. The gas meter was first produced in London, and although some English products were imported, no meters were manufactured in the United States until the 1830's. In 1849, the Boston Meter Works was formed and the utilization of meters helped to put the gas industry on a sound, economic business basis.

With the invention of the electric light, gas lighting companies were threatened with extinction. But the

energetic and resourceful men of the gas industry accepted the challenge and soon gas was being used for new domestic purposes such as cooking, heating, and water heating. With these new applications, the industry continued to grow.

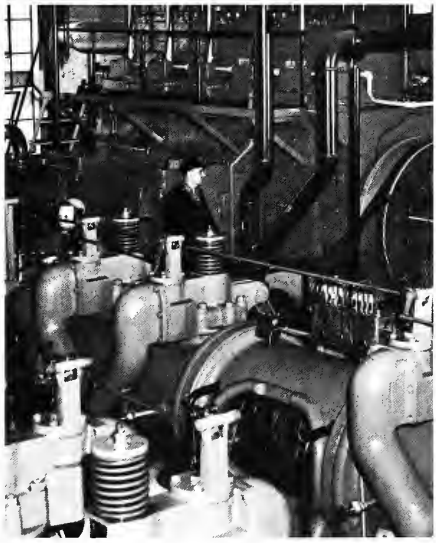
Competition among gas companies was keen during this era. Duplication of facilities was common with several companies laying pipes in the same streets. By the early 1900's, mergers helped to solve this distribution problem. For example, several companies serving Boston, Roxbury, Brookline, Newton, Dorchester, South Boston, and Jamaica Plain were consolidated into one company: Boston Consolidated Gas Company.

Today, 24 investor-owned gas utilities: Berkshire, Boston, Brockton-Taunton, Buzzards Bay, Cambridge, Central Massachusetts, Fall River, Fitchburg, Gardner, Haverhill, Lawrence, Lowell, Lynn, Mystic Valley, Nantucket, New Bedford, North Attleboro, North Shore, Northampton, Norwood, Springfield, Wachusett, Ware, and Worcester, and 4 municipal gas departments at Holyoke, Middleboro, Wakefield, and Westfield serve more than 1,000,000 Massachusetts homes, apartments, stores, and businesses in more than 200 cities and towns. Nearly 13,000 miles of gas mains deliver gas to these customers. These utilities employ more than 5,000 people. In areas of the state not yet served by underground lines, gas is available in individual tanks or bulk shipments supplied by some 350 liquified petroleum gas dealers.

Perhaps the most significant date in the recent history of the gas industry is September, 1951, when natural gas first became available to New England and Massachusetts. Prior to that year, the gas distributed by the Massachusetts gas utilities was manufactured in plants close by the cities and towns. Now, almost every gas utility in Massachusetts uses natural gas purchased from two pipeline companies, the Algonquin Gas Transmission Company and the Tennessee Gas Pipeline Company. These two companies supply the link between the gas-producing fields of Texas and the Gulf Coast area some 1,800 miles away and the Massachusetts distributing utilities. Through a vast network of underground natural gas lines which transport the cleaner, more adaptable and more flexible gas, Massachusetts companies receive a vital and new source of supply to meet the expanding needs of their customers.

Natural gas, a product of nature, is the result of a chemical reaction on marine organisms that were

More than four per cent of the electrical requirements of the New England area are now supplied through the transformation of atomic energy to electrical energy.



Pumps maintain gas pressure in hundreds of miles of gas mains reaching thousands of homes, businesses and factories.

buried in the sands along the seashore billions of years ago. The first recorded discovery of natural gas took place in Greece around 1000 B.C. However, the Chinese were the first people to put natural gas to use. Bamboo pipes transported the natural gas from the ground to large vats where it was burned to evaporate brine and produce salt.

The first evidence of natural gas in this country was a "burning spring" found in West Virginia. Fascinated by the sight of the gas bubbling up through the water, George Washington named the area as a National Park in 1775.

A gunsmith named William Aaron Hart is remembered as the first man who put natural gas to work in this country. In 1821, he dug a well in Fredonia, New York, where he had located natural gas. He capped the well, and through hollowed-out logs, carried the gas to nearby buildings where it was used to provide light. Later, he extended this crude pipeline with metal pipes and gas was used to light the Inn and several other buildings at Fredonia.

Today, almost every area of the United States is served by a natural gas pipeline. Sometimes called "The Wonder Fuel," and referred to as "pipeline plasma" when it became available to New England and Massachusetts, natural gas has a higher heat content than manufactured gas, is more controllable, and has provided Massachusetts gas utilities with an increased capacity to serve the public.

Natural gas now reaches metropolitan distribution centers through thousands of miles of underground piping.

In the home, natural gas is used for a variety of purposes such as cooking, heating, water heating, air conditioning, clothes drying, incineration and refrigeration. Oddly enough, the original purpose of the industry, which was gas for lighting, is receiving increasing popularity since modern gas lamps are returning to the driveways, patios, and lawns of Massachusetts homes.

Hotels, restaurants, laundries, bakeries, apartments, stores, warehouses, and offices are using natural gas for cooking, heating, water heating, cooling, and other important jobs. Massachusetts industry turns to natural gas for neon sign-making, hardening steel and other metals, as well as for the production of glassware, bricks, cement, procelainware, and TV tubes. Natural gas is aiding the printing industry in Massachusetts to control humidity and thereby improve the registration of the printed page.

Chemists are dissecting natural gas in the science of "petrochemicals" and are finding natural gas to be the key to the production of carbon black, fertilizers, antifreeze, plastics, synthetic rubber, insecticides, and a wide variety of other products that help provide the comforts and convenience of modern living. Natural gas is even being used to slow down the respiration of fruit while in storage to help ensure the autumn crispness of Massachusetts apples all year long.

Today, there are more than 25,000 industrial applications of natural gas and more uses are being discovered every day. Gas is serving the food industry, the machine products industry, the textile industry, the paper industry, the electronics industry, and the defense industry.

While the changes in the gas industry over the years have been tremendous, the future of the gas industry in Massachusetts may be even more startling. One of the industry's latest developments is the *Total Energy Concept* in which natural-gas-fired turbines or engines are coupled to an electric generator to produce electricity. The heat of combustion from the engine or turbine is recaptured through a heat exchanger and is utilized for heating and air conditioning. Thus, gas is used to provide heating, air conditioning, water heating, and even electricity for lighting—all in one "package." The J. M. Fields Shopping Center in Chelmsford is an illustration of a total energy installasion where the entire energy needs of this complex are supplied by natural gas.

Another recent development which will play an important part in the gas industry's future is the *Fuel Cell.* This "magic box" will produce electricity from natural gas right in the home.

From the first sputtering flame that cheered Bostonians in the early 1800's, the gas utility industry in Massachusetts has grown and continues to grow and adapt itself to meet the energy needs of the people.

THE TELEPHONE INDUSTRY

The communications story in Massachusetts has its beginning in Boston. Two acts of communication there changed the character of this land and people.

The first involved twin lanterns hung in the belfry of North Church steeple to signal the start of Paul Revere's historic ride, an event that was to trigger the American Revolution.

The second took place a century later on June 2, 1875, when Alexander Graham Bell, a professor of vocal physiology at Boston University, conducted the first successful experiments confirming the principle of his electric telephone. A few months later, on March 10, 1876, working in his laboratory with his assistant, Thomas A. Watson, Professor Bell transmitted the first complete sentence over the telephone with his now famous words, "Mr. Watson, come here, I want you."

Today, Boston continues as a focal point of communications. It is headquarters for the New England Telephone and Telegraph Company, a communications complex serving Massachusetts, Maine, New Hampshire, Vermont, and Rhode Island.

The New England company is part of the nationwide Bell System. It is closely allied with the Bell Telephone Laboratories, the research and development unit whose activities continue to make new advances in the art of communications.

The company is also closely associated with the Western Electric Company, the manufacturing arm of the Bell System, which produces telephone equipment of high reliability and quality. In Massachusetts, Western Electric's Merrimack Valley Works, located in a modern, multi-million-dollar facility in North Andover, and with a work force of some 10,000, manufactures toll transmission and microwave equipment for the Bell System companies. Some units of this equipment weigh less than half an ounce while others weigh half a ton. Associated with this plant is a branch of the Bell Telephone Laboratories.

Another milestone in research for Western Electric was reached in December of 1960 when the world's first plant built to produce quartz crystals, long a strategic component of communications systems, went into commercial production at the Merrimack Valley Works. This important event marked the successful climax of more than fifty years

of scientific experimentation and research. It also signified the emergence of the United States from dependence upon a foreign supply of pure quartz crystals. Western Electric also maintains a distributing center in Watertown which provides the materials needed by the telephone company.

New England Telephone employs more than 34,400 people with nearly 21,000 in Massachusetts. The company's investment in equipment to provide telephone service, that is cables, poles, telephone sets, and buildings, totals more than $1.6 billion in New England. Over two-thirds of this investment is in Massachusetts.

This investment is necessary to provide service for over 4 million telephones throughout the area, with 2.8 million in about 350 Massachusetts cities and towns. The New England company's manifold facilities include ship-to-shore service, mobile service to vehicles, and service to islands such as Nantucket and Martha's Vineyard.

Because the five-state area served by the company has been generally prospering, the company has shared in this increased business activity. The economic impact of an enterprise such as New England Telephone is substantial. It makes significant contributions to the region's prosperity through substantial local purchases of goods and services, tax payments, and employee payrolls.

Total telephone expenditures in Massachusetts alone for wages, goods and services purchased, taxes, etc., in 1964 totaled close to $450 million. This represents about three per cent of the state's total expenditures as measured by its personal income.

Construction expenditures in 1964 amounted to over $112 million in Massachusetts, largest in the company's history. This investment in new plant and equipment has resulted in expanded, modernized telephone service. For example, the end of the program to convert all the company's phones to dial is about completed. More than 99 per cent of all company telephones had dial service by the end of 1964. Direct Distance Dialing has been extended and 82 per cent of customers can now dial their own calls nationwide.

Virtually all the equipment for new telephone services is manufactured by the Western Electric Company, some of it at the Merrimack Valley Works. This is a significant factor in the economy of Massachusetts. The Western Electric Company in 1964, for example, purchased about $80 million of services and equipment from over 2,100 suppliers in 180 towns and cities throughout the state.

Each year Western Electric manufactures more than 50,000 different items of communications equipment ranging from telephone sets, switchboards, cables, relays, and transmitters to diodes. It has major manufacturing plants in 13 United States cities and several tributary shops working at top production capacity.

The telephone industry is in the midst of remarkable changes. With long distance calling in Massachusetts increasing at the rate of 8 per cent annually, new circuits to provide for this growth are needed in such large numbers that cable bundles would be huge and expensive. The answer is microwave, a wireless, super-high frequency, line-of-sight transmission system that is becoming as much a symbol of telephony as cables and poles. New England Telephone spends more than $1 million annually for new microwave equipment.

While New England Telephone is the major supplier of telephone service in New England, a number of independent companies work closely with the New England company. There are 66 independent companies in Maine, Vermont, and New Hampshire serving about 69,000 telephones. Three independent companies located in Massachusetts, in the towns of Granby and Richmond and on Naushon Island, just off Woods Hole, serve less than 2,000 telephones.

The facilities of New England Telephone and the nationwide Bell System are interconnected with facilities of all the independents so that message, toll, and other communications services are universally available to all telephone users.

Generally the independent companies own their own cables, while New England Telephone owns the cables up to the boundary lines of the independent company. Both have been involved in many joint cooperative efforts to provide adequate communications service to those in even the most remote areas.

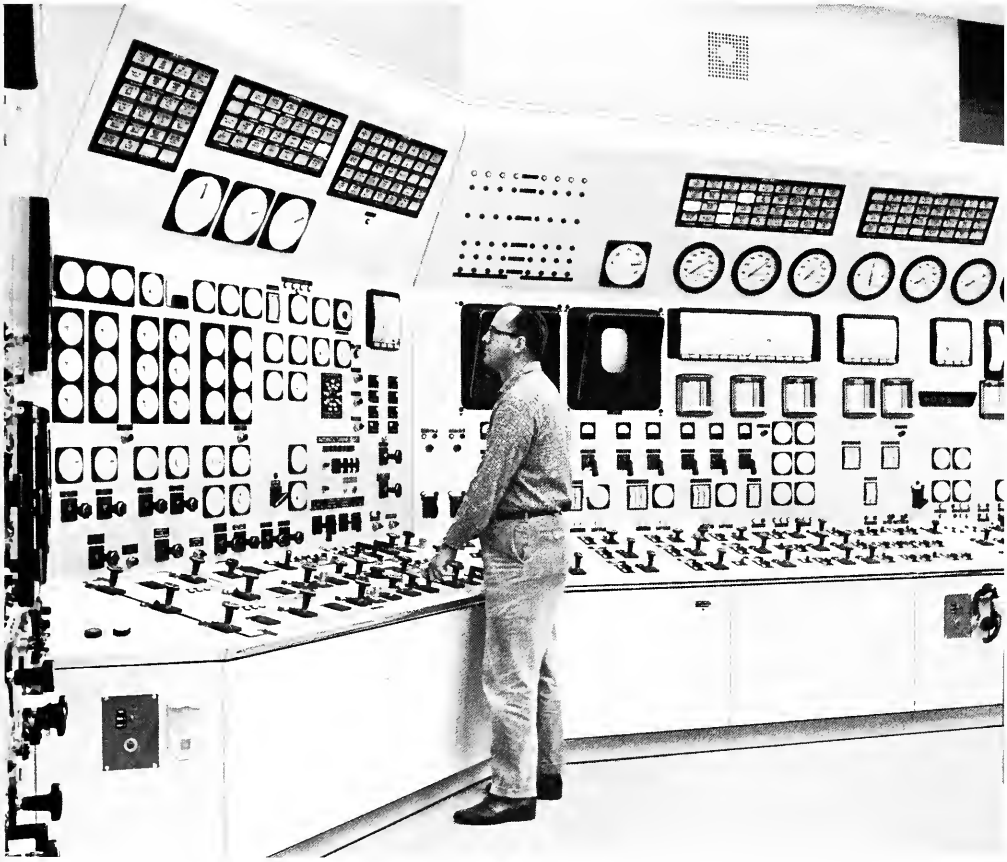
As part of the nationwide Bell System, New England Telephone is dedicated to the principle that "In Communications, Defense of the Nation Comes First." One of the primary responsibilities of the company is to furnish military organizations with the vital circuits necessary to alert, command, and control the military forces. It is also the company's responsibility to make provisions for emergency planning that will insure continuity of service under every conceivable natural or national disaster. The company also has a responsibility to provide and maintain the networks over which warning of enemy attack would be received and the population of New England warned to take appropriate action. A company communications consultant is permanently assigned at each major military installation in Massachu-

setts to serve the needs of the particular location. With him are qualified craftsmen to perform duties at the installation at a moment's notice.

The immediate and dramatic success of Telstar 1 in July, 1962, opened a new chapter in communications history and headlined the potential of a future world-wide satellite system to provide communications channels between continents. The two principal reasons for its development were to fulfill the need for more overseas circuits in the immediate future and to increase the flexibility of world-wide communications. The Telstar project is tangible evidence of the Bell System's constant effort to develop more and better communications for the nation it serves.

Since the first telephones were put into service almost a century ago, people have wondered if the day would ever come when they could *see* and *be seen* by telephone. To telephone people, there never was any doubt that it would be done—the only real question was *when*. Now, a practical beginning has been made. Bell System's Picture-Phone service now connects three major cities, New York, Chicago, and Washington, D.C. Eventually, this service will evolve for anyone who wants it, whether for business, schools, or homes.

All of this is the far reaching result of Alexander Graham Bell's early experiments in Salem, and in his Boston garret laboratory.



Dispatch Center controls the flow of electrical power over a three state area. As the demand for electrical energy rises in an area, power is stepped up to meet the need from various stations.

The Chemicals Industry

Serving industry and mankind in a myriad of ways

Everything that touches our lives is related to chemistry and the chemical industry. Today no other industry so profoundly affects our physical well-being as the chemical industry does with its multiple contributions to so many other industries. While it serves industry, it serves mankind as a whole. It is so closely interrelated to many other Massachusetts industries that it is difficult to determine where the chemical industry, as such, leaves off and another industry begins. It has a wide spectrum and it is a key industry in every sense.

The chemical industry can perhaps be defined best as any industry wherein chemical rather than physical change of materials is involved. In the chemical industry, the arrangement of atoms and molecules is altered, instead of the shape, appearance, and texture of the materials. The materials are then endowed with new properties. As has been indicated, the boundaries of the chemical industry are not rigidly set. Actually there is no single grouping that could adequately cover the many thousands of companies in the United States which have to do with chemicals or chemically formed products.

Only an insignificant part of the total output of this industry ever reaches the ultimate consumer in anything like the form in which it emerged from the chemical plant. It is also a fact that the chemical process industries, in general, are the best customers of the chemical industry.

Industrial chemistry differs from laboratory chemistry on three main points: cost, purity, and the quantity of the final product. A typical laboratory reaction yields at most a few ounces of product. In a typical industrial application, the production may reach many tons or even thousands of tons a day. In the industry's earlier days, orders for commercial chemicals were usually made in batches to fill the demand for the products as they arose. Nowadays the chemical industries operate on a practically continuous cycle of production around the clock twenty-four hours a day, shutting down only when production equipment must be cleaned or overhauled.

Man's earliest efforts to produce new material involving chemical changes date back as far as the early Phoenicians who fused sand and alkali to make glass, and many years after that, to the making of porcelain and a crude form of gunpowder by the ancient Chinese. It was not until the 13th century that an English monk, Roger Bacon, combined potassium nitrate, powdered charcoal, and sulfur in the right proportions to make the first explosive ever manufactured. This was gunpowder as we know it today.

While Europe was emerging from the Dark Ages, there arose the school of the alchemists who toiled in their crude laboratories to discover the secret of transforming the more common metals into gold or silver. Alchemy originated with the Arabs in the vicinity of the year 1000 A.D. and later found its way through Spain into Europe. During that era, a school of pharmacy flourished in Arabia. The earliest work of this school was carefully recorded by scribes, and the recording is today considered the oldest book on chemistry proper in the world. It is a compilation of all that was then known and believed. To the original Arabian chemists we owe the terms alcohol, alkali, borax, and elixir.

During the 17th and 18th centuries, chemists from many European nations, including England, France, Germany, and Belgium, contributed several basic discoveries, laws, and principles, gradually dispelling chemistry's mystery and aura of black magic. By degrees it was elevated to a status of respectability. Thus the foundations of modern chemistry were laid.

The earliest recorded chemical industry of any importance in America was concerned with the production of potash from wood ashes. In Colonial times some of the taxes owed to England were paid in potash.

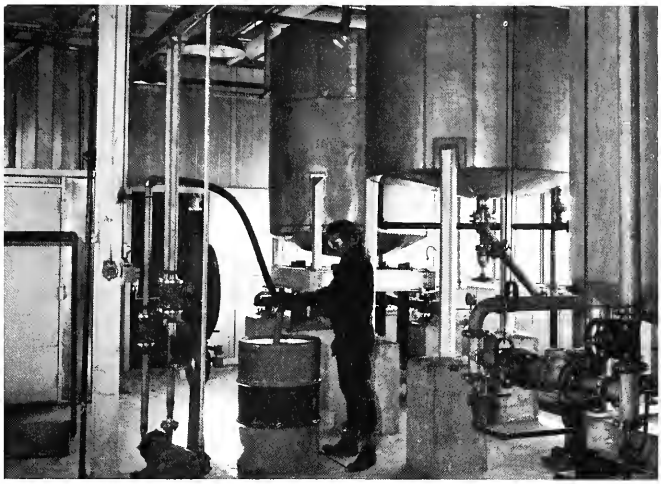
Until World War I, the development of the chemical industry was slow. The war cut off the supply of dyestuffs from Germany on which America depended. At that time, the Germans had developed the coal tar industry to a high degree and were the world's leaders in producing synthetic dyes, organic chemicals, and pharmaceuticals from coal tar. Stoppage of the flow of dyes from Germany due to the blockade seriously handicapped the textile industry, and it was predicted at that time that Americans would have to garb themselves entirely in white if the war continued. World War I gave

our fledgling chemical industry impetus and created a huge demand for ammunition and explosives. Picric acid, a chemical ingredient in high explosive shells, was manufactured at that time in large tonnage in Woburn.

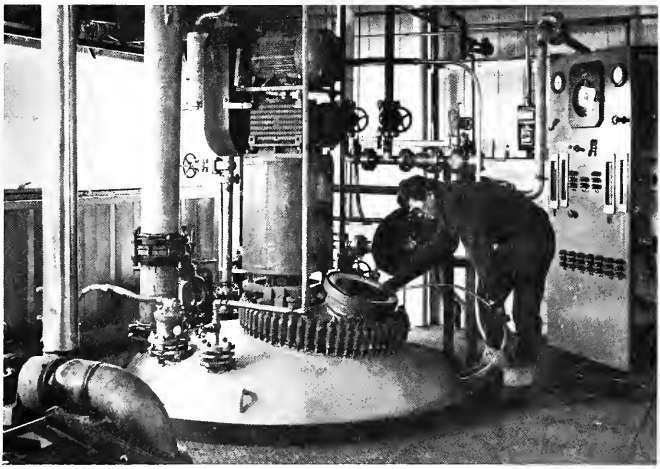
In Massachusetts, the chemical industry provides employment for more than 16,000 people, despite the fact that many of its segments are highly automated now. The annual payroll is estimated at $104,904,000, and the value of material produced is set at $279,676,000. It is also of interest to note that the chemical process and allied industries are not concentrated in any one area but are widely dispersed over nearly every geographical division of Massachusetts.

Largest segment of the chemical industry in Massachusetts consists of companies that are engaged in producing the basic materials and the intermediates from which plastics are made. These intermediates include epoxy resins, monomers, polymers, polyesters, silicone coatings, polyurethanes, polystyrenes, and elastomers. Formidable as these terms may sound, they are today common words in the field of organic chemistry and have long since ceased to be merely chemical laboratory definitions. These intermediates are used, in turn, to make molding compounds for presses, plastic foam, coatings, films, and sheeting.

Principal other segments are (1) organic and inorganic industrial chemicals, (2) cleaning and finishing preparations which include soaps, detergents, shampoos, and



Two intermediate mixing tanks and a reactor vessel installed on a scale capable of weighing 35,000 pounds as part of automated production control.



From the control panel at right an operator can charge this 2,000 gallon glass lined reactor vessel with product ingredients, control the reactions processes, and transfer the finished polymer emulsions.

toilet preparations, (3) paints, varnishes, lacquers and enamels, and (4) drugs and pharmaceuticals.

In addition, there is a sizable group of companies in Massachusetts that specialize in such areas as textile chemicals, oils, dyes, tanning agents for the leather industry, chemicals used in pulp and papermaking, chelating agents, solvents, and fertilizers. Another area of specialization is that of bottled gases, or, to be more specific, gases compressed into liquid form under high pressures and low temperatures. These are delivered to the customer in large steel cylinders. Some of these gases are utilized in acetylene welding and others are used in the fabrication of certain metals which must be worked in a controlled atmosphere free of oxygen, dust, and contaminants.

Largest producer of plastic materials is the huge Monsanto-Shawinigan complex in Springfield, whose operations are described in the chapter on the rubber and plastics industry.

At its Pittsfield plant the General Electric Company's Chemical Materials Department is another major producer of plastic resins and varnishes. It also produces phenolic molding powders which are used to make such things as distributor caps and rotors for automobile ignition systems, housings for portable tools, handles for kitchen utensils, piano keys, and washing machine impellers. Phenolic molding powders are only one of several types of plastic materials produced by this G.E. facility. Here, incidentally, is a prime example of what is termed integration. A large company makes certain products in one of its divisions which, in turn, are used in other divisions of the company. The chemical industry itself, particularly the larger chemical companies, integrate their operations as much as possible for efficiency and economy.

The Rexall Drug and Chemical Company with six divisions, including franchised Rexall drug stores all over the United States, and with world-wide operations, has five of its manufacturing facilities in Massachusetts. Plastics products for the packaging of Rexall products are their main output, although these five plants manufacture other commodities. Rexall's industrial stake in Massachusetts consists of El Rex in Holyoke, producing polystyrene resins; Massachusetts Plastics Corporation in Ludlow, manufacturing thermoformed containers; Tupco in Farnumsville, which custom molds closures for containers and tubes; the United Cotton Products Company in Fall River, which makes industrial abrasives; and Tupperware Company in Blackstone, which manufactures a line of plastic housewares including food storage containers, bowls, and dishes.

Another of the large employers in the chemical industry in Massachusetts is the Dewey and Almy Chemical Division of W. R. Grace & Co. which employs 1,400 people in its Bay State plants in Cambridge, Acton, Worcester, Taunton, and Adams. This company's line of sealing compounds for cans, glass jar caps, and many other container closures and other products is associated with the rubber and plastics industry. One of its newer developments is a plastic lining material to replace cork in soft drink bottle tops. In addition, the firm produces soda lime, meteorological balloons, chemicals which are mixed with concrete to increase its workability as well as durability, synthetic latexes used as paper coatings, vinyl emulsions used as paint bases and adhesive bases, impregnated fiber for making artificial leather, and specialty products for the automotive, graphic arts, and textile industries.

The B. B. Chemical Division of United Shoe Machinery Corporation, located in Cambridge and Middleton, is primarily a producer of chemical products for industry. It does manufacture some polymers in basic reactors. Originally organized to make shoe finishes, the product line of this division has diversified substantially, especially in the last decade. Today, shipments include dozens of adhesive types for many industries. These types include an interesting form that comes coiled on a reel. This form is melted on special equipment and used extensively in packaging. Adhesives in film form and durable coatings for both interior and exterior walls of buildings are also included in the growing line of products manufactured by this pioneer in the Massachusetts chemical industry.

General Latex & Chemical Corporation, with a manufacturing plant in Cambridge and a laboratory in Billerica, produces latex, latex compounds, acrylics, polyvinyl acetates and urethanes. Its products are sold to a wide range of industries for manufacture into a variety of products.

Emerson & Cuming, Inc., with two plants in Canton, is a leader in the field of dielectric (nonconducting) materials. This company specializes in plastic and ceramic products for the electronic industry. Among its products are microwave absorbers, plastic and ceramic foams, plastic surface coatings, and materials to shield against nuclear radiation and radio frequency interference. The company has a world-wide market with foreign sales accounting for about ten per cent of its total sales volume. Besides its Canton plants, Emerson & Cuming

operates plants in Chicago and Los Angeles, and an overseas plant in Belgium.

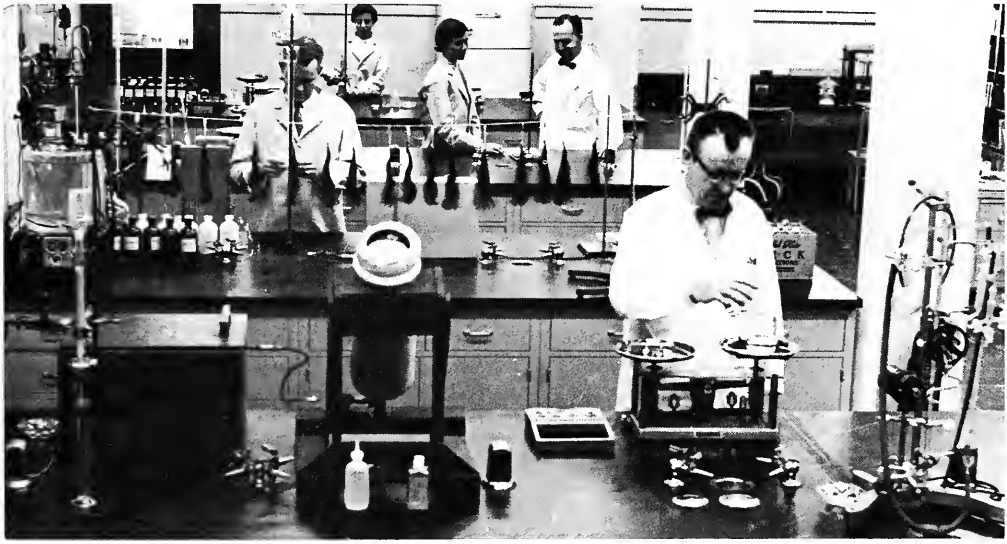
Other important companies in the chemicals-plastics segment are the Borden Chemical Company and Foster Grant Company in Leominster, Reichhold Chemicals in Andover, Haveg Industries in Taunton, Thompson Chemical Company in Attleboro and Assonet Trancoa Chemical Corporation in Reading, and Vernon Plastics Corporation in Lynn. One Massachusetts company, Tubed Chemicals Corporation, which employs 120 in Easthampton, specializes in packaging. Its principal products are plastic squeeze tubes made in a variety of sizes. The firm operates exclusively as a contract packager for companies manufacturing foods, cosmetics, household chemicals, lighter fluid, adhesives, and lubricants.

There is no sharp line of distinction between companies which produce plastics materials and those which produce other chemical products. While some companies are strictly producers of plastics, many firms split their production between plastics and other chemical products.

Rayon yarns, produced by chemically treating cellulose fibers, are made in New Bedford by the New Bedford Rayon Division of Mohasco Industries, Inc. The yarns are sold to the apparel industry for manufacture into such items of clothing as coat linings, rainwear, trouser pockets, and feminine millinery. The yarns are also used in ribbon, various types of braided materials, and shoe linings. New Bedford Rayon, one of the pioneers in the rayon industry, has operated at full capacity in all but three years of its 36-year history. The firm employs about 350 persons.

One of New England's largest and most diversified chemical plants producing heavy chemicals for industry is the Monsanto Company's Everett Plant. Formerly known as the Merrimac Chemical Company, this plant has been manufacturing chemicals since 1857. Among its principal products are alum, sulfuric acid, sodium meta bisulfite, sodium bisulfate, silica compounds, including a flatting agent for paints and an anti-slip agent, plus an acid used in the making of dyes, and a preparation used in sizing fibers. It also produces a large volume of chemicals for the plastics industry and Melamine for its Monsanto Plant in Springfield. Formerly Monsanto's Everett output went chiefly to the New England leather and textile industries, but today the pulp and paper industry is among its biggest customers.

Several years ago when dry sulfur was shipped by water from Gulf ports to Everett, a huge pile of the yellow material inside the plant was a landmark for Boston & Maine Railroad commuters riding across tracks that spanned the Mystic River. While the sulfur pile no



Cosmetics manufacturers are constantly engaged in research and product development.

longer stands there, sulfur is now brought in by tank ships in liquid form through the use of steam heated coils. It is pumped directly from the vessel into heated tanks inside the plant.

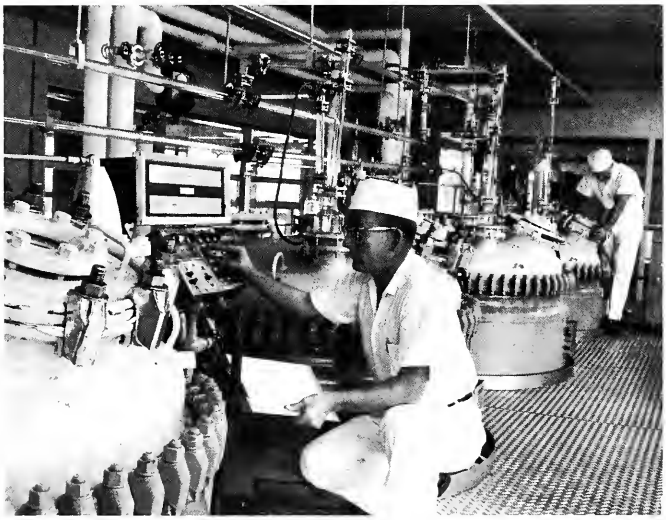
National Polychemicals, Inc. in Wilmington, which is a company owned by the British firm of Fisons Limited, produces chemical "blowing agents." These are complex organic chemicals used to make foam rubber as, for example, in the manufacture of sponge type soles for sports footwear, and to make foam plastics used in the upholstery of furniture and automobiles. It also produces a number of organic chemical additives for the rubber and plastics industry, and a separate division manufactures phenolic and urea resins for woodworking, decorative laminates, and many other uses. A Dighton company, I. C. I./Organics/ Inc., a subsidiary of Imperial Chemicals Ltd., manufactures dyestuffs and colorants, textile finishing and processing aids, as well as products for the plastics and rubber industries. This plant employs 250 people. Hercules Powder Company, which ranks tenth in size among chemical manufacturing firms in the United States, operates a plant in Holyoke which supplies resins, emulsions, sizing agents, and defoamers to the paper industry.

New England Nuclear Corporation in Boston employs about 150 persons in the production of radioactive chemicals used for research work in hospitals, universities and private laboratories.

A large chemical organization, the American Agricultural Chemical Company in North Weymouth, is located within only a few miles of where one of the first agricultural principles was put into practice nearly 350 years ago. When the Pilgrims settled nearby Plymouth in 1620, they learned from friendly Indians how to grow corn successfully. The secret? Bury a codfish in every hill of corn planted. Fish is a rich source of phosphorus. Iodine is also an essential nutrient of soils. Early Bay State farmers living near the coast gathered seaweed, dried it in the sun, burned it, and scattered the ashes over the soil. It could be truly said that the foundation of soil chemistry had its origin in applied Yankee ingenuity.

The American Agricultural Chemical Company, a leader in its field, was founded more than one hundred years ago. It is a pioneer in the field of agricultural chemicals used in farming and home gardening. Fertilizers and acids that go into their manufacture are made at the North Weymouth branch plant of this national company.

Any discussion of the chemical industry in Massachusetts must consider that Massachusetts is deficient in raw materials. Most of them must be shipped into Massachusetts from other areas of the country or imported from foreign sources. About the only materials produced for this industry in Massachusetts are lime and a limited tonnage of animal products, which, here again, are raw materials for other industries. Treated lime goes into the form of fertilizers. Glue from the skins of fish has been manufactured in Gloucester for many years by LePage's, a subsidiary of the Papercraft Corporation. The major portion of this plant's production is devoted to a complete line of consumer adhesives and pressure-sensitive tapes. The Stauffer Chemical Company in Woburn manufactures animal glue from the offal of the leather industry. The hundred-year-old Union Paste Company in Boston uses more than 800 different chemicals in producing its line of more than 300 adhesives for industrial customers. The company's products are widely used in the shoe industry and in the production of paper bags and cardboard cartons.



Section of a preparation room for local anesthetic solutions.

Special adhesives are made for cigarette paper, for envelopes, and for labels on bottles and cans.

Soaps and detergents involve chemistry in their manufacture, and several nationally-known brands are made here in Massachusetts by Procter & Gamble's regional plant in Quincy. The list includes Camay, Ivory, Duz, Ivory Snow, Ivory Flakes, Tide, Cheer, Oxydol, Dreft, Dash, and Spic & Span. In addition, this Quincy company manufactures special cleaning products used in industry and by institutions. Two by-products of its soap making operations are glycerine and a supplement for animal feeds. The Quincy plant started operating in 1940 with Oxydol as its only consumer product. In 1952 it expanded its facilities by erecting a six-story building and installing processing equipment for the manufacture of synthetic detergents.

Another well-known manufacturer of detergents is Standard International Corporation, which has facilities in Holyoke, where it produces Lestoil household and industrial detergents as well as many other well-known consumer products. These include Bon Ami cleansers, Red Cap Refresh-R air deodorizers, Scuffy shoe polish, Jet Spray window cleaner, Dust 'n Wax furniture polish, Tidy Home paper products, and home laundry products.

Several smaller Massachusetts companies specialize in soaps formulated for the needs of textile manufacturers. There are well over 100 companies in the state engaged in manufacturing cleaning, polishing, and finishing preparations.

A score of Massachusetts manufacturers combine their lines of cleaning agents with polishes and other household products. One such company is Stanley Home Products, Inc. of Westfield, which began its manufacturing operations in 1931 in an old tobacco shed. Its first product was brushes. Now expanded to a facility in Easthampton of more than eleven acres, it produces a line of approximately 250 items that include household cleaning products, cosmetics, and grooming aids. Its management attributes the company's growth to a novel selling plan called the "Stanley Hostess Party Plan," which enlists the selling efforts of tens of thousands of housewife dealers throughout the Commonwealth, nation, and a number of foreign countries.

In Malden, the K. J. Quinn & Company has been manufacturing leather finishes and shoe polishes since 1880. It produces many of its own basic ingredients. The company also has plants in Canada, Mexico, Spain, West Germany, and Italy. A leading producer of oils and greases for the tanning industry is the Salem Oil & Grease Company, whose products are made from oils derived from animals, vegetables, sea animals, and fish. Several other producers of oils, waxes, and greases are located in the Lynn-Salem area and principally serve the shoe industry.

Adhesives and gelatin depend upon chemistry for their production, and a large annual tonnage of both these products is made here in Massachusetts. The Chemical Division of the Compo Shoe Machinery Corporation of Waltham and Mansfield is the largest manufacturer of permanent sole attaching adhesives in the world. In addition to the many adhesives used in the shoe industry it also manufactures industrial adhesives used in the automotive, aircraft, and textile industries. In Boston, the International Shoe Machinery Corporation makes adhesives used in the shoe industry.

UBS Chemical Company, now a division of the A. E. Staley Manufacturing Company, has its main offices and production facilities in Cambridge, and a pilot plant and additional production facilities in Marlboro. The firm was established in Lynn in 1903 to make chemicals for the New England shoe industry. From that point the company has grown and expanded into other areas of chemical production centered around the use of natural and synthetic latices. In addition to producing adhesives for shoes and other industrial uses, UBS produces polymer emulsions widely used in floor polishes and latex paints as well as urethane compounds for surface coating applications. The company is recognized as a pioneer in the development of polymer emulsions.

Two-thirds of the Eastman Kodak Company's annual requirements for photographic gelatin are produced in Peabody by the Eastman Gelatine Corporation, a subsidiary company. The plant has an annual payroll of about 300 and consists of more than thirty buildings covering an area of 400 acres. The Atlantic Gelatin Company in Woburn, a subsidiary of General Foods, is another large producer of gelatin.

In the field of "allied products," there are more than 50 manufacturers of paints, varnishes, lacquers, and enamels in Massachusetts, the oldest of which is Devoe & Reynolds Company in Malden. This company, founded before the Revolutionary War, absorbed Wadsworth, Howland & Company in 1925, which had been making paints in Massachusetts since 1845. A firm of manufacturing chemists in Chelsea, Samuel Cabot, Inc., founded in 1877, has made notable

contributions to the paint industry. Its first products were coal tar derivatives, pitch, and creosote. The founder of this company, Samuel Cabot, invented shingle stains, and is credited with revolutionizing the paint industry. He was among the first to use titanium dioxide in white paints, which keeps white paint from yellowing with age, and he also developed a formula for non-fading green paints and blue paints. Other large paint manufacturers in Massachusetts include four companies in Everett: Carpenter-Morton Company, established in 1840, Kyanize Paints, Inc., West Paint & Varnish Co. and E. I. duPont deNemours & Company, Inc. Benjamin Moore & Company in Milford, and the National Lead Company in Boston are others.

Masury Young Company in Boston is a large producer of soap, wax and seals for floor maintenance. Howe & French Inc., which has factories in Weymouth and Everett, makes lacquers, adhesives, enamels and paint.

Inks are an important segment of chemicals and allied products. The Carter's Ink Company in Cambridge is Massachusetts' largest manufacturer in this field. In addition to a wide variety of marking, writing, stamping, and recording inks, Carter's also makes carbon paper and typewriter ribbons, felt tip markers, stamp pads, household and commercial adhesives, and a wide line of products for the stationery field.

It would be difficult to go into a drug store anywhere in the country today and not be able to find dozens of items on its shelves and in its show cases that originated in Massachusetts. One example is shaving cream made by Gillette Safety Razor Company, which also makes shaving lotion in its big plant in South Boston.

In the specialized field of cosmetic chemistry, John H. Breck Inc. of Springfield has achieved world-wide recognition for producing fine preparations for the care of the hair. Originally established in 1908 by the late Dr. John H. Breck for giving of professional hair and scalp treatments, the company pioneered in the concept of specialized hair preparations for specific hair conditions and is now the world's largest producer of liquid shampoos. The excellence of its preparations coupled with an extremely effective and unusual advertising campaign incorporating the "Breck Girl" pastel portraits have elevated John H. Breck Inc. to a position of leadership in the hair preparations industry. The company currently employs nearly 500 people in the Greater Springfield area, and distributes its preparations both nationally and to 67 foreign countries.

Massachusetts has more than twenty companies, the majority of them small, producing drugs and pharmaceuticals. Several widely advertised proprietary medicines such as Father John's Medicine, made in Lowell, and Lydia Pinkham Compound, made in Lynn, are Bay State products. Largest of those firms manufacturing pharmaceuticals is Astra Pharmaceutical Products, Inc., a subsidiary of a Swedish firm, A/B Astra. This plant, located in Worcester, and employing 400, is the world's largest producer of local anesthetics. It also makes iron preparations for intravenous injections. Medicinals are also made in Dighton by I. C. I. /Organics/Inc. Two nationally known products, Absorbine and Absorbine, Jr., are produced by W. F. Young, Inc., manufacturing chemists in Springfield.

A Beverly manufacturer, Ventron Corporation (formerly Metal Hydrides Inc.) is a manufacturer of a diversified line of products, including reducing agents used in the pharmaceutical, pulp and paper, and the textile industries.

In addition to its chemical line of products manufactured at its Danvers plant, Ventron manufactures unique non-ferrous metal powders, and its wholly owned subsidiary, Allegheny Electronic Chemicals Company produces electronic crystals for the electronics industry. Alfa Inorganics, Inc., an affiliate of Ventron, offers thousands of unusual inorganic chemicals for research purposes.

Borden Chemical Company has three plants in Massachusetts. The largest is in Leominster and is a leading producer of latex emulsions used to make water-based paints, adhesives, and coatings for paper and textiles. This plant also makes plastic resins used in the manufacture of floor tiles, phonograph records, and many other plastic products. A Borden plant in Peabody makes industrial adhesives and coatings. In North Andover the company makes extruded plastic tubing for the aircraft and electrical industries, and for the medical profession. The North Andover plant also produces garden hose and clear, flexible plastic packaging film.

Raffi and Swanson, Inc. in Wilmington, which employs 120 people, specializes in the formulation and manufacture of protective and decorative coatings for fabrics, paper, metal, wood, plastic, and rubber products of many kinds. Its ink division produces rotogravure and flexographic inks for the packaging industry.

Another important contributor to many manufacturing processes these days is industrial gases. Air Re-

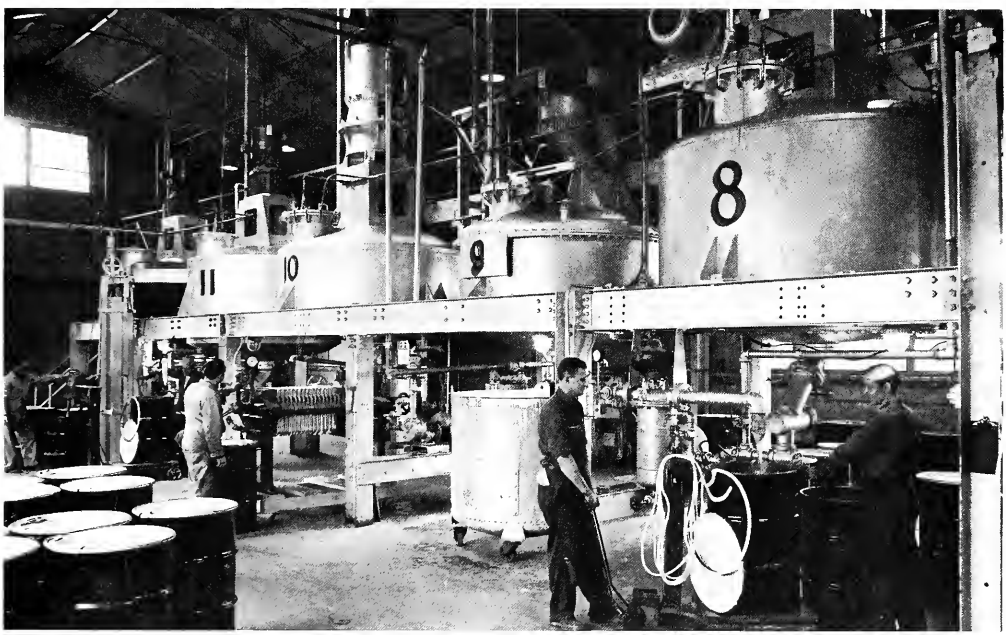
duction Company's plant in Acton makes a variety of these gases used in both manufacturing and in fabricating metals. Among this company's principal products are bottled nitrogen, used in the process of food freezing and other phases of the food industry to prevent the spoilage of certain fruits due to overripening. Nitrogen, being an inert gas, prevents oxidation. Air Reduction Company also produces oxygen, used in combination with acetylene, to cut metals. These gases are delivered to industrial users in liquid state in strong steel cylinders. The company also produces helium and argon, which for many years were considered as "rare gases." These two gases are used in the fabrication of titanium and other hard-to-work metals suited for components of satellites and missiles.

The Linde Company Division of Union Carbide Company, one of the top twenty chemical companies in the United States, operates a unit in Sudbury that makes compressed acetylene gas. The plant also supplies oxygen, nitrogen, argon, and helium in both liquid and gaseous form, plus hydrogen gas.

The Liquid Carbonic Corporation, a division of General Dynamics Corporation, has two plants in Massachusetts producing gases. In Cambridge it makes carbon dioxide, the gas that makes soft drinks effervesce, and dry ice which is carbon dioxide reduced to a solid state. At its Tewksbury plant, the company makes acetylene, nitrogen, helium, and other gases for industrial applications. This plant also produces oxygen used in hospitals, as well as other medical gases.

National Cylinder Gas Division of Chemetron Corporation has gas producing plants in Malden and North Grafton.

Massachusetts, in comparison with several other regions, is not a large chemical producing state, principally because of its basic lack of raw materials. Instead, the chemical industry is concentrated here in but a few large companies and a substantial number of smaller companies that specialize in a wide variety of chemically based products for both industrial and consumer use. But again, the heritage of the industry dates as far back as 1716 when Benjamin Franklin and his father made soap in Boston; to 1735 when Thomas Plaisted was given a grant of 100 acres to make potash; and to 1836 when A. D. Phillips patented the first phosphorus match in Springfield.



High-powered turbo-mixers cut and blend clear lacquers and clear stocks which are filtered and clarified as they are drained from the tanks.

The Rubber & Plastic Industry

Bay State pioneers a major industry

THE RUBBER INDUSTRY

A substance upon which the welfare of modern mankind depends is rubber. The wheels which transport him, his goods, the feet on which he and his children work and play are all shod with rubber. Rubber plays a vital part in industry and commerce. It protects man from the elements. It is almost impossible to imagine the world in the days before the discovery of rubber. Yet, despite years of effort and countless expenditures of time and money, it was a child of chance.

Pure rubber, made from latex, the sap of a South American tree, had defied man's efforts for many years until it was put to practical use here in Massachusetts in 1839. Before then, the product became sticky when exposed to heat, brittle when exposed to extreme cold. Bankruptcy, running into millions of dollars, was the fate of early entrepreneurs.

The perseverance of a single man, climaxed by a stroke of luck, made rubber as we know it today. Charles Goodyear, a native of Connecticut, suffered all his life from privations and poor health and was an admitted failure when he moved to Woburn after years of fruitless experiment in New York City. He had learned one lesson: rubber must be compounded with another element to make a workable product. He tried many combinations before he merged his ideas with those of another diehard Yankee, Nathaniel Hayward. He then began experiments with sulphur as the most promising agent to mix with the rubber.

It was a sample of one of his compounds of rubber and sulphur which Goodyear had with him on that momentous January day in 1839 when he set forth for a routine visit to A. E. Thompson's village store on Main Street in Woburn.

As he joined the conversation around the stove in Thompson's store, the inventor, as usual, started one of his discourses on rubber and showed his latest sample. Somehow the ball of material accidentally slipped from his fingers and landed on the red-hot stove. When Goodyear moved to retrieve his sample, he was amazed to find what contact with the intense heat of the stove had done to it. It was charred and it curled like leather, but it had not melted and it was not the least bit sticky.

Excited by the apparent change in the structure of the rubber, Goodyear spent the next few days testing his new product. He found, much to his delight, that it could withstand both heat and cold without deteriorating.

Through a lucky accident this unluckiest of men had finally learned that treatment with heat was the secret of successful utilization of rubber. Thus was born the process known as vulcanizing which heralded a new era for the all-but-defunct rubber industry. Massachusetts became the birthplace of the modern rubber industry. Here in the Bay State, the technical breakthrough that made possible the literally thousands of useful products now made with this valuable material was made.

Today there are more than 100 manufacturing plants in Massachusetts producing hundreds of different kinds of rubber products and employing nearly 21,000 persons. Footwear is Massachusetts' leading rubber product, and the largest employer in the rubber industry in the state is the B. F. Goodrich Footwear Company plant in Watertown, formerly known as the Hood Rubber Company. This plant alone has more than 5,000 employees manufacturing all types of waterproof footwear and a complete line of canvas shoes.

Other large manufacturers of rubber and canvas footwear are the Converse Rubber Corporation in Malden, whose subsidiary, Tyer Rubber Company in Andover, produces, in addition to rubber and canvas footwear, protective garments for sportsmen, air goods for sportsmen, and rubber covered rolls, and the Randolph Manufacturing Company in Randolph. Several Bay State companies make rubber heels and soles for shoes, including American Biltrite Rubber Company, which has factories in Chelsea and Stoughton, Quabaug Rubber Co., North Brookfield and Avon Sole Company in Avon.

In addition to being a producer of rubber soling material for the shoe industry, Plymouth Rubber Company, Inc., located on the original site of Paul Revere's copper rolling mills in Canton, manufactures more than half the rubber bands used in the world, as well as vinyl plastic sheeting for the upholstery, automotive and home furnishings trade, rubberized sheeting

for hospital beds, and electrical tapes of both rubber and plastic.

Southeastern Massachusetts is the home of four large rubber companies. In Fall River, the Firestone Rubber & Latex Products Company is a leading producer of foam rubber for upholstery and "lubricator foam," which is used in the journal boxes of railroad cars in place of the oily rags and waste of former days. Other products include rubber thread, gaskets for baby food jars, hose for railroad airbrakes, electrical insulation materials, and molded rubber parts for the transportation and material handling industries. Adjacent to this plant on Mt. Hope Bay, the company has its own deep-water docking facilities and brings in liquid latex by tanker ships direct from the Firestone rubber plantations in Liberia.

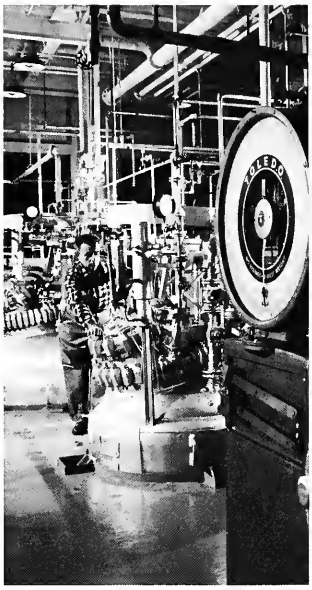
Globe Manufacturing Company in Fall River is the world's largest producer of extruded rubber thread and one of the leading producers of synthetic elastic thread. These elastic threads are used in both men's and women's hosiery, in underwear, in foundation garments, in swimwear, and in various woven and knitted stretch fabrics. The company, which started in 1945 with only six persons on the payroll, now employs 400.

The Goodyear Tire & Rubber Company's plant in New Bedford is among the world's largest producers of bicycle tires. Their annual production runs to well over 5,000,000 tires. The plant also produces rubber blankets and other items for the printing industry. Also in New Bedford is the Acushnet Process Company, a leading manufacturer of golf balls. The Acushnet ball is sold exclusively through "pro" shops at golf clubs and the firm has 7,000 such sales outlets. The company is also a leading supplier of precision molded rubber parts to the automotive, aircraft and appliance industries.

Massachusetts boasts another major producer of golf balls, that of A. G. Spalding & Bros., Inc. of Chicopee, who are nationally-known producers of a variety of sporting goods. The United States Rubber Tire Company, also in Chicopee, is one of the largest employers in western Massachusetts, employing over 2,000 persons in the manufacture of automobile and truck tires. The Chicopee plant is the largest tire producing plant east of the Alleghenies. The company also has tire and tube factories in Detroit, Indianapolis, Los Angeles, Eau Claire, Wisconsin and Opelika, Alabama.

Manufacturing equipment for another sport is the Stowe-Woodward, Inc. plant in Newton, which makes rubber-covered bowling balls. The firm also makes rubber-covered rolls used in machinery in the paper and textile industries.

The Dewey and Almy Chemical Division of W. R. Grace & Company has three plants in Massachusetts producing rubber-containing products, located in Cambridge, Acton, and Adams. The division's products include sealing compounds for metal cans and other containers, textile print and offset printing



Pilot laboratory for the development of specialized synthetic rubbers and other polymers.

White sidewall bicycle tires before and after molding and vulcanizing.

blankets, weather balloons, artificial leather base and shoe components.

One of the old-timers in the rubber industry in the Bay State is Boston Woven Hose & Rubber, now a division of American Biltrite Rubber Company of Chelsea. In its Cambridge plant, it specializes in all kinds of hose—garden hose, fire hose, industrial hose—as well as belting for various industrial uses, rubber stair treads, and rubber matting.

Other factories in the rubber industry in the state make products which range from such commonplace items as rubber bands to rubber doors for industrial plants. Rubber flooring, waterproof garb for sportsmen, beach balls, electrical plugs, rubber toys, baby pants, windshield wipers, and ice bags are but a few on the list of Massachusetts-made products.

Since World War II there has been a remarkable change in the industry from the use of natural rubber to the use of synthetic rubber. Today the industry consumes nearly three pounds of synthetic to every pound of natural rubber.

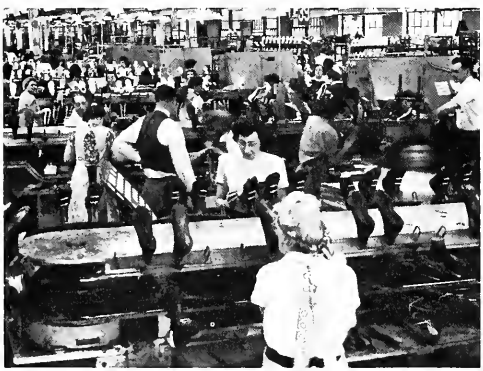
Massachusetts firms shared in the development of synthetic. Even before World War I, a process for making synthetic rubber had been developed for the Hood Rubber Company by L. P. Kyrides and Richard Earle. The process was costly but it produced a rubber which could be used satisfactorily in making footwear. The first privately-owned synthetic rubber plant in the country in World War II was that of the Dewey and Almy Chemical Company in Cambridge. Now a division of W. R. Grace & Company, Dewey and Almy today manufactures specialized synthetic rubbers for many types of industry.

THE PLASTICS INDUSTRY

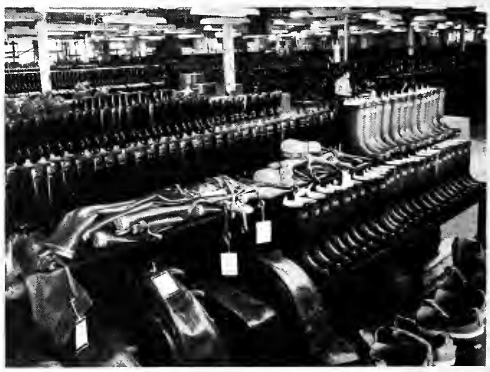
Closely allied to the rubber industry is the plastics industry, in which Massachusetts is also a leader. Today the processing in the two industries is similar and a number of Bay State factories make products in both rubber and plastics.

The Longhorns of the West provided material for the product which was the forerunner of plastics. The great horns of this breed of early beef cattle had a spread of five feet. In early factories, mostly in Leominster, these horns were cut into six-inch sections, boiled in oil, split, rolled flat, and shaped into combs and other articles. The business, which thrived through most of the nineteenth century, with a total of 24 factories in Leominster alone, ground to a halt at the turn of the century. This was principally because the wiry Longhorn was becoming supplanted by better beef animals, most of them hornless. This created a distinct shortage of horns for the factories.

About thirty years before this, an inventive Albany, New York, printer named John W. Hyatt discovered the first plastics material. This was a mixture of pyroxilin, made from cotton linters and nitric acid, mixed with camphor to make a material called celluloid. This was the material used in Leominster factories when they converted from horn as a raw material to plastics for combs and toilet articles. The trouble with this early material was that the essential elements were the same as those used in high explosives and gun cotton. The early saga of plastics is blurred with accounts of fires and explosions. It was formed in big blocks and shaved down on a planer into sheets of the desired thickness. These were then hung on a line, like wet clothing, to dry.



A corner of one of the longest "making" rooms in the world, showing canvas footwear in process of assembly.



Thousands of pairs of rubber boots for firemen, waders for fishermen and winter overshoes are inspected and packed for shipment.

Following the invention of celluloid, many other products with the suffix "oid" appeared on the market, including viscoloid manufactured in a Leominster plant that the duPont Company later acquired.

For more than forty years celluloid remained the only basic material of the plastics industry. Then, in 1909, Dr. Leo Baekeland successfully combined phenol and formaldehyde to provide the first phenolic plastic material, which was given the trademark name "Bakelite" in honor of its inventor.

Dr. Baekeland developed techniques which made it possible to use his plastic for a variety of commercial products, such as marbleized clock bases, electric iron handles, and restaurant table tops.

The next big break-through in plastics came in the late 1920's, when German chemists produced a granular material, called cellulose acetate, which could be molded by a new process known as "injection molding." When placed in a machine under heat and pressure, the material was liquefied and forced into a steel mold shaped to the exact design desired for the finished product. The first of these machines used in America was imported from Germany but gradually American-made machines dominated the field.

Injection molded plastic products soon flooded the market, supplanting wood and metal products, such as toys, tool and knife handles, and countless other articles. Tough, strong, and light, plastic provided the answer to thousands of demands.

It is impossible to say which firm in this country first made articles by the injection molding process because scores were experimenting. Foster Grant Company of Leominster, that city's largest employer, was one of them. Defying the skepticism of others in the industry, the firm succeeded in designing its own injection molding machine that could use cellulose acetate and in 1931 became the first plastics molder in the country to engage commercially in injection molding operations. It now has 1,500 on its payroll and is the world's largest maker of sun glasses. There are forty plastics firms in Leominster, which proudly proclaims itself as "The Pioneer Plastic City."

Other important plastics operations in Leominster include those of the duPont Company, which makes plastic toothbrushes and combs; Commonwealth Plastics Corporation, plastic buttons, school supplies, and jewelry; Plastic Academy Products Corporation, housewares; and Tilton & Cook Company barrettes, combs, hairpins and cigarette cases.

The manufacture of molds used to produce plastic products is an important allied industry in Leominster. There are about as many concerns making molds, dies, and machinery for plastics as there are in the plastics industry itself. The Standard Tool Company is one of the largest of these firms, making molds as well as automatic molding machines. A trade magazine once commented: "Leominster molds and dies are being used the world over. Leominster methods for producing molds and dies and machine tools are being used in the four corners of the world." To train its youth in machine tool and mold-making techniques, Leominster has a trade school which offers practical courses in these fields.

In Springfield, Monsanto Company and its wholly-owned subsidiary, Shawinigan Resins Corporation, have one of the largest and most diversified plastics manufacturing operations in the country. They employ more than 2,800 persons. Monsanto came to Springfield in 1938, when it purchased the Fiberloid Company, a pioneer plastics manufacturer, and bought Fiberloid's interest in Shawinigan Resins.

Fiberloid was the first to develop automobile safety glass made with sheets of cellulose acetate laminated or sandwiched between layers of glass. In 1937, when another product called polyvinyl butyral had been developed to eliminate yellowing and white spots in the early safety glass, Shawinigan Resins built a plant in Springfield to produce this product for Fiberloid to convert into safety glass laminating plastics. Today, polyvinyl butyral is the only plastic used in automobile windshields.

The Springfield plant of Monsanto has the world's largest calender for making plastic film or sheeting. It supplies a wide variety of plastics raw materials to many plastics molding plants in the Bay State and elsewhere. Its research and engineering laboratories develop ideas and provide technical services to plastics plants around the world.

Another company in the Springfield area that has long manufactured products of pyroxylin, rubber, and plastics is the C. F. Church

Plastic squeeze tubes were first produced in Massachusetts.

Division of American Radiator & Standard Sanitary Corporation. This Division is a sizable manufacturer of school furniture component parts made of woodflour, and complicated custom molded industrial plastic products, as well as a wide variety of sheet covered, rubber, solid plastic and alkyd toilet seats. In 1963, the C. F. Church Division consolidated the operations from three plants into the present location in Monson. In a recent capital improvement program, the company installed an injection molding machine capable of molding, in a single operation, a part or piece weighing up to fifteen pounds.

Outside of the concentration in Leominster and Springfield, the plastics and allied industries are scattered quite widely throughout Massachusetts.

At Lawrence is the Bolta Products Division of General Tire and Rubber Company. This plant is one of the largest manufacturers of plastic trays and it is one of the leading suppliers of vinyl sheeting for upholstery in automobiles and furniture.

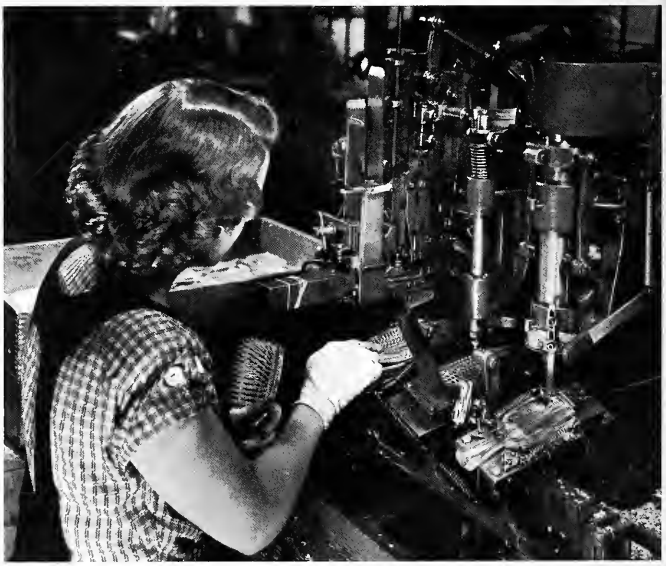
The Maynard plant of the American Can Company manufactures products which include plastic tubes and a specialized container which is composed of a polyethylene body with two metal ends. Even though the basic plastic tube is a relative newcomer to the field of packaging, it is now widely used in a large number of consumer products including shampoos and cosmetics. The plastic tube, which is squeezable, can be printed attractively in four colors and has the advantage of being unbreakable, soft to the touch, and convenient for storing and use. Massachusetts can claim the first United States production of the plastic squeeze tube as it took place in Maynard some ten years ago. Now American Can produces millions of these important packages in two United States locations and Canada. Licensees for the package are located throughout the world.

In Northampton is the oldest and largest toothbrush manufacturer in America: the Pro-phy-lactic Brush Company, now a subsidiary of the Standard Oil Company of Ohio. This company began making plastic products in 1866 from a compound consisting of resin, shellac, and carbon black. Today it can make a million toothbrushes a week and also produces hairbrushes, bottle caps, and plastic dinnerware.

In Wilmington the Sweetheart Plastics Division of Maryland Cup Corporation makes disposable plastic containers for packaging ice cream, coffee, and other food products. It also makes plastic straws and sundae dishes. Maryland Cup has three other plants in Massachusetts and employs a total of about 700 persons in the Bay State. Its Cambridge plant makes hot drink cups and in Chelsea it has a plant producing soufflé cups. The firm's Eastern Baking Company division in Cambridge makes ice cream cones.

Seal Sac Inc. in Fall River, which makes plastic food bags, bowl covers, appliance covers, and garment bags, recently announced plans to expand its operations and increase its work force from about 300 to nearly 500 employees. In Worcester another large manufacturer of plastic products, Dapol Plastics Inc., makes a line of plastic housewares and garden supply items.

The Worcester Moulded Plastics Company at Worcester, one of the oldest custom molders of thermoplastics in the country, is one of the largest producers of parts for radio and TV cabinets. It also molds complete plastic cabinets for other



Stapling machine anchors bristles in hair brushes.

manufacturers. In Clinton, the Van Brode Milling Company makes plastic spoons, forks, dishes, and automotive parts. At Braintree, the large plant of the Armstrong Cork Company employs nearly 1,000 persons. Products include both rubber tile and vinyl plastic tile for flooring, roll coverings for textile machinery, gaskets, and foamed plastic pipe insulation.

Haveg Industries, Inc., subsidiary of Hercules Powder Company, was founded in 1929, and has since pioneered in the field of engineered plastics. Its Taunton Division, which employs approximately 700 people, is considered to be one of the largest, if not the largest, and most complete custom molding facility in existence. In its 175,000 sq. ft. manufacturing area, it engineers and produces a complete range of molded thermosetting and thermoplastic materials, including molded products with unique mechanical, electrical insulation, and heat resistant properties. These products serve the electrical, electronic, explosive ordnance, small hand-power tools, and communication markets.

In addition to its plastics line, the Haveg Taunton Division is a leader in the design and fabrication of silicone rubber aircraft seals, precision molded and extruded parts, and various sheets and die cuts. These products are sold to all of the airplane and helicopter producers in this country for both commercial and military aircraft.

Three companies in Massachusetts manufacture decorative plastic laminates, widely used for furniture tops, kitchen counters, and interior paneling: Reiss Associates Inc. in Lowell, Melamite Corporation in Lawrence, and Parkwood Laminates Inc. in Wakefield.

Two fields in plastics which have had tremendous growth are wire-coating and packaging materials. Massachusetts companies have shared in the growth in both of these fields.

One of the largest producers of high quality plastic insulated wire and cable products is ITT Wire and Cable Division of the International Telephone & Telegraph Corporation in Clinton.

A very new plastic manufacturing process, and one that shows great potential for growth in Massachusetts, is called "blow molding." Common examples of products made by the blow molding process, such as detergent bottles, squeeze bottles, and other liquid containers, can be seen in ever increasing numbers on the shelves of any supermarket or grocery store. Simply stated, the blow molding process begins when a tube of material is extruded into a die or mold which is of the design desired by the customer. After the die closes around the extruded tube, air is injected into the tube which, because it is in a semi-molten state, stretches to conform to the interior design of the die.

Two nationally known companies have recently opened branch plant operations in Massachusetts and are now among the largest producers of blow-molded plastic products in the state. They are Owens-Illinois Glass Company, whose factory is located in Newburyport, and Brockway Glass Company, Inc., now operating in Hyde Park.

The list of Massachusetts-made plastics products is as endless as the one for the State's rubber industry. It includes plastic heels for women's shoes, plastic toys, baby rattles, dog dishes, flower pots, garment bags, garden hose, clerical collars, plastic skylights, tableware, hair brushes, fishing accessories, kitchen counter tops, jewelry, printing plates, disposable plastic cups, and packaging materials, to mention but a few. The plastics industry in Massachusetts also manufactures a whole host of products for industrial use.

In all, about 250 plastics firms in the state provide employment for some 12,000 persons.

The importance of the rubber and plastics industry to the economy of Massachusetts can be measured at least in part by the fact that approximately 33,000 are employed, earning more than $175 million in salaries and wages per year. In 1963, these two industries contributed $298,272,000 to the Massachusetts economy.

The Textile Industry

A heritage since 1636

From the sheep ranches of the Mountain States, from the cotton plantations of the Old South and giant farms of the Far West, from synthetic fiber plants of the industrial East, from Australia and Egypt—from all corners of the world, fibers funnel into Massachusetts, by water, rail, and truck, to be spun and woven into a myriad of textile products, for use in clothing, in industry, and in homes.

Massachusetts founded the industry which today employs two million Americans making textiles and apparel with natural and artificial fibers produced by another two million Americans.

In spite of a century of change, the Commonwealth textile industry still employs more than 41,000 workers, produces an annual payroll of $185,856,000, and contributes value added to our economy of $316,293,000 each year.

Massachusetts is noted for the diversification of its textile products. They range from cotton, woolen, and synthetic fabrics for fashion-sensitive women's clothing and men's apparel to specialized industrial items, synthetic fiber and wool felts for computers, machine tools, printed circuits, storage batteries and communication equipment, and vinyl plastic coated fabrics used in baby carriages and hot rods.

Massachusetts products also include fiberglas insect screening, fish lines, elastic webbing, braids and cordage for use in shoes, girdles, garters, stretch fabrics, underwear and sporting goods, upholstery fabric, blankets, clothesline, bookcloth, hat bodies, carpets and rugs, and marine cordage.

Massachusetts concerns are engaged in every step in processing raw fibers to finished products. Some sort fibers, some scour and comb them, others spin yarn, and others weave, knit, braid, and make lace.

Massachusetts ranks among the nation's largest producers of wool fabrics and wool yarns. It is also the largest producer of textile machinery. It has the largest wool combing and scouring operations and is number one in the production of non-woven felts and coated fabrics. It ranks among the first three states in producing cordage and twine and in dyeing and finishing cotton and synthetic fabrics. The Port of Boston alone annually handles 200 million pounds of wool and other fibers valued at $150 million.

In addition to the consumption of great quantities of fibers, Massachusetts mills use large amounts of dyestuffs, chemicals, lubricants, fuels, as well as electrical power and supplies.

Textile machinery plants in Massachusetts produce more than half of the original textile machinery made in the country, and consume thousands of tons of steel and other metals in the process.

The Bay State's heritage of textiles began in the 17th century. As early as 1633, scarcity of cloth was a problem and prices were regulated. A few years later, subsidies were offered for the manufacture of cloth. This was soon dropped in favor of legislation directing that each town produce its quota of yarn and cloth.

In the 1700's, vocational schools for instruction in spinning and weaving were established, spinning societies were formed, "spinning bees" were held, and a so-called "spinning craze" was widespread. A group of English, and another of Irish, weavers moved to the Bay Colony and greatly enhanced the skill and quality of her cloth. The latter group also introduced the potato to North America.

The Navigation Acts and the colonial boycott of English goods gave impetus to domestic manufacturing of cloth. By 1770 it was proudly noted that at the Harvard Commencement all graduates wore cloth made in New England.

After independence from England was won, the industrialization of Massachusetts and her sister states in the North moved ahead with increasing momentum. Although the first mill for processing of wool was established in Rowley as early as 1636, and the first cotton mill operated in Beverly in 1787, the technological revolution in machinery and the use of power, particularly water power, got under way with the manufacturing of the spinning frame by Samuel Slater in 1789. The next thirty years saw the development of the power loom for weaving and the application of water power to other textile operations.

The development of new machinery, new processes, and new fibers has never ceased. This development grew with leaps and bounds during the nineteenth century. Mills and cities were built

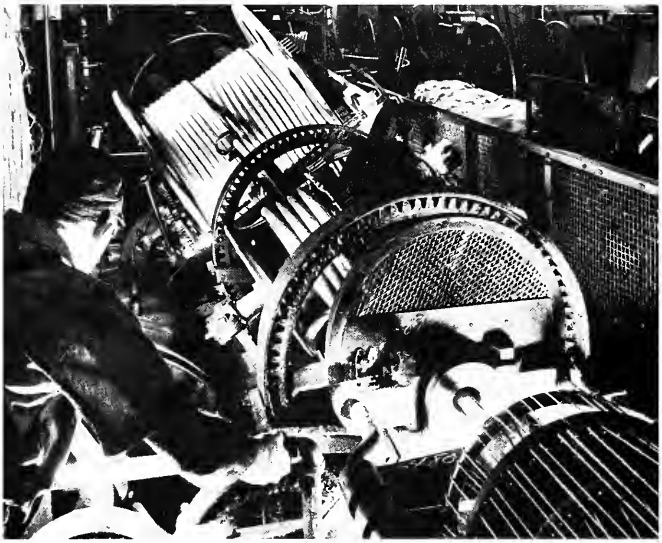
wherever water power existed or could be developed. Lowell, Lawrence, and other Merrimack Valley communities were founded as textile communities. They grew and prospered. Fall River, New Bedford, the Blackstone Valley, Worcester, Holyoke, Springfield and Adams grew with the continuing industrial revolution. By the end of World War I, there were 220,000 citizens employed in the Commonwealth's textile mills.

The names of the founders of the mills are synonymous with the history of our state, and too numerous to list. Such names as Lowell, Cabot, Lawrence, Stevens, Durfee, and a host of others, are identified with the financing and building of the mills and the communities which grew around them.

In the early years of the nineteenth century, textile employees were largely recruited from the farms of New England. As the demand for cloth grew and the industry expanded, jobs became available to successive waves of immigrants from Ireland, Canada, Europe, and the Azores.

Industrial growth gave Massachusetts the men and power to defend the Union during the War Between the States. The first three Union casualties of the Civil War were textile workers from Lowell and Lawrence, who, in answering President Lincoln's call for help, were killed in Baltimore on their way to the Capitol.

Massachusetts and her textile mills had a share in the turmoil of industrialization and labor disputes. A population, both native and im-



The tougher fibers that make up the yarn for rope must be drawn and twisted according to exacting specifications for the kind of rope desired.

The finished fabric must be inspected and graded.

migrant, which had been oriented for centuries to an agrarian life, found adjustment to factory work in an industrial society difficult and frequently vexing. Growing competition from mills with lower wages, principally located in the South, and repeated national depressions, shattered the dream of a stable, secure community, and a fierce battle for survival followed. After World War I, the textile capacity of the country far exceeded its needs. Massachusetts and other New England states started the shift to a more diversified economy as the Southern states grew in textiles. This was usually painful and the scars still can be observed in many textile communities. An example of this dramatic shift that has occurred in the textile industry was an early 1965 announcement that the last cotton textile mill in Fall River had closed down permanently. At its high point during World War I, Fall River had 122 cotton textile mills which employed up to 30,000 persons.

Today's modern mill is a far cry from the factories of only a few years ago. As the result of constant research and development, the speed and productive capacity of textile equipment has greatly improved. A vast array of wash and wear, wrinkle resistant, and permanent press apparel is now available. The modern plant is well lighted, air-conditioned, humidity-controlled, and clean. The plant of today is a highly mechanized model of industrial efficiency, usually operating around the clock, three shifts a day. The output per hour has been increasing constantly, particularly since World War II, and is among the highest of any major industry. The industry is becoming increasingly capital intensive.

The newly founded Merrimack Valley Textile Museum in North Andover has fascinating exhibits on the development of textile machinery and an excellent library of source material. The Slater Museum in Pawtucket, Rhode Island, also contains interesting historical exhibits of importance to the textile industry.

The division of labor, a hallmark of the industrial revolution, is notable in textile operations. Most mills have a minimum of one hundred different jobs. In addition to the manufacturing positions, there are a host of jobs in designing, engineering, sales, marketing, research, and development. Many of the major mills of the country maintain selling offices in Boston, and our mills maintain sales organizations in New York and other major cities.

Textiles are taught in most of the major technical colleges, including M.I.T., and, of course, in Lowell Technological Institute, originally Lowell Textile Institute. Textiles are also taught in Southeastern Massachusetts Technological Institute. There is a wealth of opportunity in the industry throughout the country for all varieties of people, including scholars, designers, engineers, researchers, salesmen, and manufacturers.

The Massachusetts Department of Commerce and Development subdivides the Bay State's textile industry into many categories. Some of these are: broad woven fabrics; narrow fabrics; knit goods including underwear and hosiery; bleaching, dyeing and finishing; floor coverings including carpets and rugs; yarns and threads; cordage and twine; felt goods; and miscellaneous other fiber products that include surgical dressings and filters.

In a chapter of this brief length it is not feasible to cite all of these textile companies and identify them by name. However, a brief description of some of the larger firms and also some of those whose operations have unusual aspects will help to illustrate the importance of this industry to Massachusetts and the economic contributions the industry continues to provide.

In the category of broad woven fabrics is the Hayward-Schuster Woolen Mills, Inc. in East Douglas. This company engages in the manufacture of fine woolens for apparel manufacturers in the field of men's wear, women's wear, and children's clothing. It employs about 500 people and is one of the largest single, completely integrated woolen mills under one roof in New England. Also located in East Douglas is the Hayward Woolen Company, which produces specialty fabrics woven from cashmere, camel's hair, and vicuna.

J. P. Stevens & Co., Inc. is an old-established textile company with widespread operations in other states as well as in Massachusetts. Two mills in North Andover and one mill in Dracut employ more than 1,000 workers. One of the North Andover plants, Stevens Mills, is located on the site of the original Stevens Woolen Mill built in 1813. Some of the woolen goods produced in these plants are known throughout the country by the trade names of Hockanum, Forstmann, and Worumbo.

Other well-known producers of woolens and worsteds in Massachusetts who employ from 250 to 1,000 workers include the Waucantuck Mills in Uxbridge, Rindge Industries in Ware, Anglo Fabrics Company in Webster, Strong Hewat & Co. Inc. in North Adams, Stanley Woolen Company, Uxbridge and J. J. O'Donnell Woolens, Inc. in Grafton. Smaller in size is the Barnes Worsteds Inc., Kingston and the Charlton Woolen Co. in

Charlton. This latter company was founded 125 years ago.

In all, there are about 100 Massachusetts textile mills engaged in the production of broad woven fabrics of all fibers. In addition to the companies previously mentioned, other large companies in the group of broad woven fabrics using materials other than wool are Ansonia Mills, Inc., a subsidiary of International Stretch Products, Inc., in Taunton, manufacturers of elastic fabrics for the foundation, swimwear, sportswear, automotive, and shoe trades, the Hoosac Mills Corp. in North Adams and the Lynn Textile Mills in Holyoke.

Massachusetts also has about 25 companies listed under the category of wool scouring, wool combing, and wool tops. Wool tops are a semiprocessed raw material that form the basis for the production of finished textiles. To the wool manufacturer, they are what flour is to the baker and what steel plates are to the shipbuilder. Prominent companies in this classification are the Barre Wool Combing Co. Ltd. in Barre, Marriner & Co. Inc. in Lawrence, and Southwell Combing Co. in North Chelmsford.

Stevens Linen Associates, Incorporated of Webster is the sole surviving completely integrated spinning and weaving linen mill in the United States and was first established in the nearby town of Dudley in 1846 by Henry Hale Stevens, woolen manufacturer, and brother of the founder of M. T. Stevens Co. Although linen had been spun and woven in the homes of Massachusetts immigrants from the British Isles, this was America's first linen mill. Today, it is the only textile mill in the United States that produces fabric from the raw stock, flax. At the factory, flax in its raw fiber form, imported from such countries as Belgium, Egypt, Canada, Peru, Chile, and Argentina, is carded, spun, woven, bleached, dyed, and finished into linen towels and toweling.

The Stevens Linen Associates originated screen printed linen calendar towels, first marketed in 1954. The company also makes solid color towels, napkins, gift sets, and printed place mats.

Berkshire Hathaway Inc. of New Bedford, employing 1,900 people, has roots that go back to the old whaling days. When the whaling industry declined with the advent of "coal oil" or kerosene for illuminating uses, men of vision began to invest in a new field, that of textiles.

One of the earliest mills formed in New Bedford was the Acushnet Mill Corporation. Its president was Horatio Hathaway, a member of an old seafaring family; and under his direction the company prospered. Several years later, in 1889, he started a second mill in New Bedford known as the Hathaway Manufacturing Co. It was founded as a cotton spinning and weaving mill. During the 1920's, Hathaway increased the mill's production with the use of synthetic fibers then being introduced into the textile industry. In 1955, Hathaway merged with the Berkshire Fine Spinning Associates, which was one of the largest fine cotton goods companies in the United States.

Raw fibers must first be pulled apart and cleaned before undergoing the many processes required to turn it into cloth.

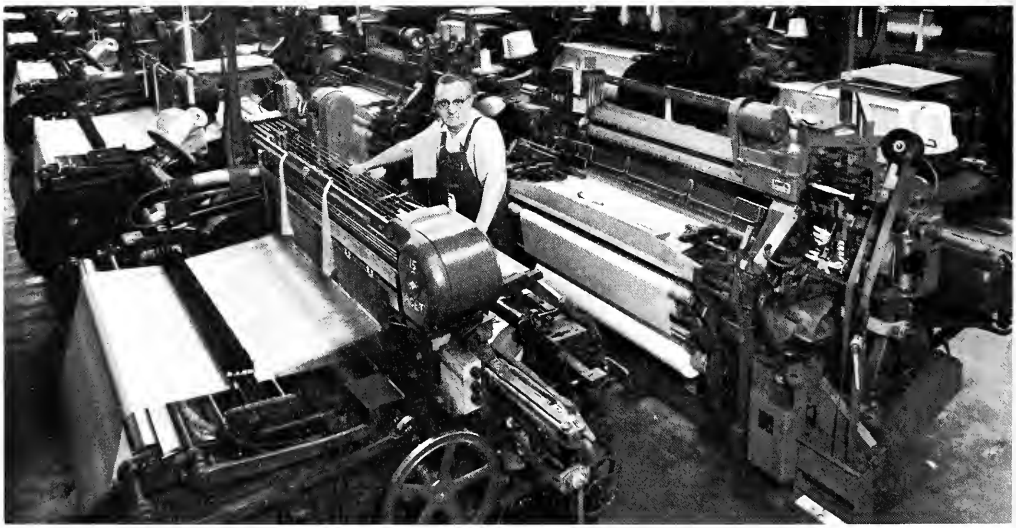
Since then, however, all but one of the Berkshire Fine Spinning Associates' mills have been closed due to the competition of Southern mills and foreign imports.

Berkshire Hathaway still rates as one of the leading textile manufacturers in New England and its New Bedford plant is rated as a model of production design and efficiency. Its products are sold all over the United States, Canada, Europe, and Australia. Its principal output consists of colored yarn, cotton ginghams, rayon linings, dacron marquisettes, dacron and cotton blend batistes, rayon twills, and taffeta woven from cotton, synthetic yarns, and blends of cotton and synthetic staples.

Of the some fifty manufacturers listed under the category of narrow fabrics and textile smallwares in Massachusetts, the Wm. E. Wright & Sons Co. in West Warren is prominent. It employs 750 people plus an additional 250 in an affiliated company in Williamsport, Pennsylvania. Credited as the country's largest manufacturer in its particular field, its product line consists of bias tape, rick rack, seam binding, blanket binding, laces and trimmings, gift tie ribbon, window trims, and garment trimmings for women who sew at home. Founded in the rear of a store in downtown New York City in 1897, it later moved to Orange, New Jersey, and in its third stage of expansion, elected to come to Massachusetts in 1934.

A considerable volume of elastic webbing is produced annually by the textile industry in Massachusetts. Principal manufacturers are Thomas Taylor & Sons in Hudson, now in its second century of operations, Elastic Web Division of the Kendall Company in Stoughton and Easton, and the United Elastic Corporation in Easthampton.

United Elastic is the kingpin in this category. In fact it is the country's largest company in the elastic webbing industry, engaging the services of 2,800 people, 1,000 of whom are employed at its main plant in Easthampton, its plant in Littleton, and its Conant Houghton division in Lowell. Outside of Massachusetts, it operates plants in Connecticut, Virginia, North Carolina, Alabama, and one in Canada. United Elastic was formed in 1927 after a merger of four older established Massachusetts companies, some of whose beginnings date back to 1860 or earlier. Easthampton has been manufacturing elastic fabrics since they were first introduced into this country from England more than a hundred years ago. United Elastic products made in Massachusetts include narrow woven elastic fabrics for apparel, particularly foundation garments, rubber textile tape and golf ball



Hundreds of looms in plants throughout Massachusetts weave cotton, wool, silk, synthetics and varying combinations of each to meet industrial and consumer fabric needs.

thread, and also wide woven elastic fabrics for the foundation garment industry.

Bleaching, dyeing and finishing are textile processing operations in which some Massachusetts companies specialize. On the other hand they may be processes which integrated textile manufacturing companies perform in their own plants, indicating the complexity of the textile industry and its many ramifications. The five largest companies in this category from the standpoint of people engaged are the Bancroft Arnold Finishing Co. in Adams; the Chicopee Mfg. Corp. in Chicopee; the Cranston Print Works Co. in Webster; the Lancashire Textile Processing division of the Calvine Mills in New Bedford; and United Merchants & Mfg., Inc. in Fall River. Another Massachusetts company which might also be included in this category is the Defiance Bleachery in Barrowsville, whose main activities consist of the bleaching, mercerizing, dyeing, and finishing of textile fabrics. Defiance Bleachery also specializes in the chemical conversion of fibers and fabrics and is a holder of several patent rights.

There are nearly fifty yarn and thread mills in Massachusetts which contribute in large measure to the Commonwealth's textile output. The two largest manufacturers are Malden Mills, Inc. in Lawrence and Fitchburg Yarn Co. in Fitchburg. Emile Bernat & Sons Co. in Uxbridge is one of the nation's largest branded distributors of hand knitting yarns.

Twelve companies in Massachusetts' textile industry specialize in twine and cordage. Biggest of all is Plymouth Cordage Co. in North Plymouth, whose extensive plant is near Plymouth Rock where the Pilgrims landed. In the world of fibers there is hardly a name better known than Plymouth Cordage. Founded in 1824 under a Massachusetts charter, it continues 141 years later to operate under its original charter without change in form or corporate name. The company was originally organized to produce rope for use primarily by the whaling industry and by fishing and merchant marine fleets. In later years it became known as the world's largest ropemaker. It is the Number One cordage manufacturing operation in the United States.

Its Cordage division produces standard hard fiber ropes along with all types of currently used synthetic ropes such as nylon, dacron, polyethylene, and polypropylene. It also produces ropes made from various combinations of these synthetics. Other hard fiber and synthetic fiber products produced by Plymouth are tieing twines and baler twines used in baling hay, and twisted paper products for use as cable fillers and carpet backing yarns.

Of late years, the company has diversified into other lines besides cordage. It now operates five other subsidiary companies. It has two other New England plants, the W. W. Cross division of Plymouth Cordage Industries, Inc. in Jaffrey, New Hampshire, manufacturing tacks and nails, and the J. C. Rhodes Co. in New Bedford, making eyelets for shoes and other industrial uses. Its plant in Warwick, Virginia, does paper twisting, and its Athol division in North Carolina produces vinyl coated fabrics for wall coverings and for the upholstery trade. At its Wilson & Toomer division in Jacksonville, Florida, it manufactures fertilizers for commercial farming and home gardening.

Another old established Massachusetts company is the Samson Cordage Works in Shirley, well known in the trade as a producer of braided cotton cordage and extruded plastic cordage. Samson sash cord has been used by builders for many years. In window frames, in combination with counterbalancing weights, it facilitates the opening and closing of windows. With the development of synthetic fibers, Samson Cordage is producing a wide range of synthetic braided ropes for marine, fishing, and many specialty purposes. Samson synthetic lines, manufactured at the Shirley plant, are used to recover all Mercury, Gemini and Apollo capsules, as well as for many other highly specialized and technical purposes.

Textile fibers play a vital role in another small segment of the textile industry in Massachusetts: the manufacture and preparation of bandages, surgical dressings, and related accessories. A leader in the industry is the Kendall Company in Walpole, where its Fiber Products Division is located. Employing more than 1,100 people, Kendall produces absorbent cotton, pharmaceutical coil cotton, head and neck bands, and milk and dairy filtering supplies. It also is prominent in the manufacture of non-woven fabrics, a burgeoning offshoot of the textile industry. Kendall also operates a branch plant in Griswoldville.

Although classified as a finishing plant, the Chicopee Manufacturing Co. in Chicopee is an important supplier to this field. Founded as early as 1823, since 1916 it has been a wholly owned subsidiary of Johnson & Johnson, world's largest producer of surgical dressings and related products. During 1916 when World War I was reaching its height, Johnson & Johnson was faced with the almost hopeless task of furnishing the Allies with

enough surgical dressings to meet their mounting needs. The acquisition of Chicopee Manufacturing at that time enabled Johnson & Johnson to bridge the gap.

Another leader in its field is Tampax Incorporated which employs nearly 500 people in its Palmer plant to manufacture the world's best-selling brand of internal sanitary protection for women.

Felt, a material of many constructions, widely used in industrial and decorative applications, accounts for a share of the textile output of Massachusetts. There are fewer than ten producers in the state. One of them traces its beginnings to more than a century ago. This is the Bacon Felt Company which was established in 1825 in Winchester. In 1951, it relocated in a larger plant in Taunton. Its mill manufactures many types and shapes of felt products ranging from tiny bobs used for polishing in the dental and jewelry trades to four-inch-thick wheels, 48 inches in diameter, used for polishing marble. It is the oldest manufacturer of felt in the United States and has contributed many major improvements to the art of felt-making.

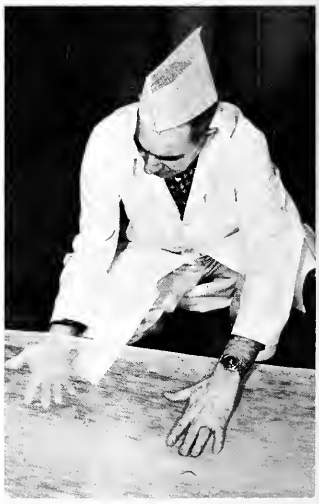
American Felt Company, the world's largest manufacturer of pressed wool and synthetic fiber felts, with factories in several states, has a Massachusetts plant in Franklin. Here the products include apparel and decorative felts, slipper and shoe felts, felts for pennants and athletic lettering, drapery and upholstery felts, industrial filter felts, and even felts used in pianos.

Draper Brothers Company in Canton, established in 1856, manufactures knitted linings for gloves and overshoes, yarn for sweaters, and endless woven felts for papermakers. They are also the only concern in Massachusetts making these custom-made papermaker's felts, whose manufacture requires special skills and equipment not usually found in the textile industry, such as looms as wide as 650 inches.

The Felters Company, with headquarters in Boston, operates from Millbury a felt facility originally organized in 1899. While this plant continues to process as an entirely integrated mill pressed felts for end uses covering many important industries such as aviation, automotive, chain store, shoes, Armed Services, and many specialty items such as absorption of vibration, its facilities have been expanded to cover non-woven fabrics and needled filtration materials utilizing the growing list of miracle, chemical fibers for specific end uses. A complete research laboratory is maintained from which future expansion will be emanating. The normal complement for the mill's production runs from 300 to 350 people.

Clark-Cutler-McDermott Co. in Franklin, founded in 1911, is an-

The soft ropes of fibers are called "slivers." When the yarn is finished as many as 46,000 of these slivers will be twisted into a single strand.



Although this thermoplastic nonwoven fabric has a delicate appearance it is used for tough industrial jobs such as insulation for electric motors where heat resistance is important.

other well-known producer of felt products such as needle-loomed jute felts and carpet linings, anti-vibration pads and machine mounts, shoe felts and insulation felts. The company's first products in 1911 were horse blankets!

Another important producer of felt is the National Felt Co., located in Easthampton.

Also in the non-woven fabrics segment of the industry is Pellon Corporation in Lowell, which makes bonded fabrics (fibers held together by a banding agent such as rubber) that are used as interlinings for garments.

Twenty-two companies produce all the carpets, rugs, and floor coverings made in Massachusetts from textile fibers. The largest is the well-known Roxbury Carpet Company, with headquarters in Framingham. Two other important producers are Oxford Mills, Inc. of Ware and Loomweave Rugs & Carpets, a division of Congoleum-Nairn, Inc., in Lawrence.

Haartz-Mason Inc. in Watertown produces coated fabrics and mechanical rubber products. In Framingham, the Hodgman Rubber Company makes rubberized and plastic-coated fabrics, hospital sheeting, and coated sporting specialties.

Massachusetts has twenty-six companies in the textile field that specializes in the production of vinyl coated and impregnated fabrics, two of the largest of which are Goodall Vinyl Fabrics in Reading and the Weymouth Art Leather Co. in Braintree. Goodall Vinyl Fabrics, which originally started out as a rubber manufacturing company in the 1890's, is now a division of Burlington Industries. Furnishing jobs to nearly 500 people, it is the largest employer in the town of Reading. Its principal products are materials for the upholstery of furniture and automobile interiors, and for making shoes, luggage, and handbags.

Besides the companies which produce finished knit garments, there are a number of mills in the state which make knit fabrics. Two of the larger producers are Alamac Knitting Mills Inc., with plants in Springfield and Palmer, and the Ames Textile Corporation in Lowell.

Massachusetts has the distinction of having the oldest woolen mill still in operation at its original location in the United States. This mill is the North Billerica Company's Faulkner Mills in North Billerica, which was founded in 1811. It is the third oldest textile mill in the nation.

To say the textile industry has undergone a series of many changes during the past four decades would be an understatement. What is important now in the textile industry of Massachusetts is its new viewpoint which argues well for its continuing future.

Elastic yarn is covered with a protective coating of cotton or synthetic strands.

The Apparel Industry

Clothing the family is a big business in Massachusetts

From its inception apparel manufacturing has played an important role in the industrial growth of Massachusetts. Massachusetts is the third largest market in the nation for apparel. It is a leader in the production of men's rainwear and women's sportswear. It also offers a diverse sampling of family apparel makers. A pioneer in the development of ready-made garments and mass production techniques, "Made In Massachusetts" has become synonymous with quality and value.

The settlers in Massachusetts brought with them the tools of their trade and many households had spinning wheels and looms. Women made the cloth and clothing for the entire family. The greatest economy was practiced and hardly a colonial suit or dress survives, since most of them were cut up to make clothing for the children.

Tailoring remained a family affair in the new colony until the late 1600's when a handful of shops, located near Boston Harbor, were occasionally pressed into making a quantity of garments to outfit a crew prior to sailing from what was then America's most active port. Repetition of these demands prompted store keepers to produce ready-to-wear garments. This meant finding workers who could finish the rough clothes, and the answer was the beginning of apparel contracting in this country. The tailors secured the services of hundreds of housewives who were generally the spouses of sailors. These first clothing stores were called "slop shops," a name derived from the name of a slop room of a ship where clothing supplies were issued, stored, and sold.

The rise of the apparel industry parallels the development of textiles. New England, and Massachusetts in particular, became a natural site for the manufacture of finished apparel because of its proximity to the textile mills of Lowell, Lawrence, Haverhill, New Bedford, and Fall River. The first stages of apparel mass productions were initiated in Massachusetts by John Simmons, a gentleman who is more lastingly remembered for his endowment which established Simmons College. Two notable events in subsequent years greatly expanded the mass method of production: the invention of the sewing machine by a Bostonian, Elias Howe, and the Civil War.

Between 1830 and 1835, Simmons cut men's suits to standardized sizes in his shop. The pieces were then sent out to be stitched by women in their homes, and finally the garments were returned to the shop to be finished and pressed. The advent of the railroad in the 1840's greatly extended John Simmons' area of distribution. He was probably the first apparel manufacturer to send salesmen outside the state, and his garments were worn throughout America's rural communities. There was no stigma attached to wearing ready-mades in the country, although city dwellers still preferred to patronize the custom tailor on a made-to-measure basis.

Simmons is generally credited with introducing the crease in trousers. The crease was made when the garments were returned to the plant for finishing, and subsequently the garments were packed away in stacks of a designated height. Pressure of the clothing produced the same straight wrinkle down the center of the pant. For a time the customer would press the crease out, since it was a social disadvantage to be seen in a ready-made suit. The crease was the badge of ready-made apparel for some time, but as demand and production increased, the badge became universal. Due to the large number of women which Simmons employed, on a contractual basis, he bequeathed a portion of his estate to the establishment of the Simmons College for vocational education. Appropriately, the Prince School of Retailing at Simmons remains one of the great centers for the study of merchandising.

Around 1860 there was a rash of men's wear manufacturing; a few suppliers of boys' wear existed but there was not a single dress manufacturer in the entire country. Women's clothing found its first commercial footing through the dressmaking departments of large retail stores. "Babies" were the vogue prior to the Civil War. These were miniature mannequins which had been imported from Europe and dressed in the newest fashions. Orders were placed based on the doll's attire.

Primarily the manufacturing of clothing remained male-oriented, and when the Civil War was de-

clared production rapidly increased. Army orders and patterns gave a tremendous impetus to manufacturers. The industry rose from an estimated $4.5 million in 1860 to $17.5 million product value in 1870.

Boston was the center for the outfitting of the Union Army, and a large quartermaster depot was located at the corner of Washington and Boylston Streets. The Loomis Company, which was given the contract to outfit the National Guard, discovered that it could not produce ready-made garments in sufficient quantity and convinced the Army that standard sizes were the order of the day. This prompted the government to make further investigations into the dimensions of the soldier, and the business of sizing took an important step forward. The results of their study revealed that the average male was 5 feet 8 and three-quarter inches high, waist circumference of 34 inches and weight between 150 and 160 pounds. On this basis a reasonable measurement for small, medium, and large uniforms was reached. With the exception of a few imported patterns that had been brought from England by William C. Browning of Browning, King, and some makeshift patterns by earlier manufacturers such as John Simmons, this was the first scientific approach to fitting the masses.

Boston was the center of the clothing world in 1875 and the manufacture of apparel was the city's largest single industry. Among the early firms were Talbott & Co., J. Peavey and Bros., Whitten,

Many hundreds of patterns must be produced as each new style of garment is created.

A cutter follows a pattern tracing, cutting many layers of cloth at the same time to the exact shape of the pattern.

Burdett and Young, Al Shuman and Co., and the Leopold Morse Company.

Through the end of the 19th century Leopold Morse Company, typical of the city's clothiers, had their garments cut and trimmed on the premises and then sent out to be finished in smaller contractor factories. The firm employed 3,500 workers in 1899 and the average selling price of a man's suit was $15. The cost to manufacture a sack coat was $1, trousers 40 cents and a vest 25 cents. During this period the Knockabout suit was a famous Boston product, and several manufacturers could boast of more than a million dollars in annual volume.

Following the end of the Civil War the demand for mass production of men's wear levelled and production facilities were turned towards women's garments. The census of 1870 reported women's clothing production had reached the $1 million mark. Although dressmaking departments continued to thrive for the affluent, women of modest means turned to shop clothing. These were first called "Hand-Me-Downs," derived from the earlier establishment of second-hand shops where garments were resold.

Women's wear came to be a significant factor by slow degrees. First hoops became a large industry. Then cloaks and suits followed. By the close of the century, waists, lingerie, sleepwear, skirts, and accessories had joined the list of manufactured products.

Another metamorphosis occurred within the garment industry as it approached the 20th century. The system of contractors was gradually replaced by the factory. The larger firms completed all processes of manufacture in their own plants, and new firms opened with all necessary equipment under one roof.

Specialized sewing procedures require individual handling of each garment as in this attaching of a pants pocket.

This brought into sharp contrast the two systems of manufacturing, the sweating system and the factory system. The sweating, or contracting system, consisted of farming out the materials for garments which were made up by individual men and women, usually in their homes. This system was prevalent until 1890. Factories had taken over a large portion of the industry by 1900, and at the same time the garment worker became unionized.

The national origin of the garment worker also changed over the course of years. The earliest tailors were of Irish or English extraction. From the middle to the end of the 19th century, men of German and Polish extraction became prominent in the industry. Great numbers of immigrants from Central Europe entered the clothing picture in the 20th century. The plant of today is cosmopolitan with workers representing every race and religion.

Massachusetts and the New England area has been the biggest male rainwear manufacturing center since Yankee ingenuity created a garment whose material was varnished with fish oil more than a century ago. These garments were favorites with New England fishermen as well as sailors visiting the Boston port. The "Fish Brand" label was introduced by the A. J. Tower Co. in 1836, and their first product was clumsy to wear and sticky to the touch. However, in 1870, this company incorporated the same water resistant material in a more flexible garment that was suitable for both land and sea.

More than sixty per cent of the nation's rainwear is manufactured in the state. Leaders include Cable Raincoat, Wales Manufacturing, and Plymouth Manufacturing, all based in Boston. The A. J. Tower Co. has been merged with the H.

M. Sawyer Company and Sawyer-Tower, Inc. is located in Watertown. Massachusetts is the birthplace of the finger tip coat and the reversible and nylon raincoat, in addition to the original slicker.

The Northeast is the second largest producer of outerwear, accounting for more than twenty per cent of the nation's men's and boys' clothing. Massachusetts has long been known for its topcoats, overcoats, and heavy outerwear including leather and sheep-lined coats, snow suits, and skiwear. Situated in a densely populated area which normally has a long, cold winter and an abundance of snowfall, it was natural for manufacturers to design special garments which answered the particular needs of the region's inhabitants.

In the topcoat field, the single breasted chesterfield introduced by the Barron Anderson Company of Boston in 1903 remains a trade standard. Other large contributors to the tailored clothing field include Trimount Clothing Co., Inc., home of the "Clipper Craft" label and the Malcolm Kenneth Co., both based in Boston. Others include Anderson Little Inc., of Fall River, and Grieco Brothers Inc., Lawrence. Picariello and Singer Inc., located in East Boston, is one of the large boys' clothing producers. Another leader in the boys' field is Calvin Clothing Corp. in New Bedford.

Massachusetts has given birth to many of the outerwear ideas now generally accepted throughout the country. Foremost of these are the windproof golf jacket, the corduroy coat, and the alpaca-lined coat. A leader in outerwear is Gloucester's Cape Ann Manufacturing Co. This company's roots can be traced to the nineteenth century when it supplied oiled outerwear to fishermen. Today the "Mighty Mac" label is world-wide. Two Lawrence firms, Ace Sportswear Co. and William Barry Inc. are also large outerwear manufacturers for men and boys.

Of the approximate 36 overall and work clothes manufacturers that existed in 1918, one firm has retained its dominance, the M. Hoffman & Co., Inc. known by its "Dubbleware" brand.

Two of the more important nationally known shirtmakers have facilities in the state, the C. F. Hathaway Company, Inc., Lowell, and The Arrow Company, A Division of Cluett Peabody & Co., Inc., Leominster. Other important sources are Shutzer Mfg. Co., Inc., Lawrence, and Shelburne Shirt Company, Inc. of Fall River. The Asher Manufacturing Company in Fitchburg is one of the leading pants producers.

F. Barton Brown designed the first men's stocking supporter in 1878. Named the "Gentlemen's Boston Garter," it was turned over to the George Frost Co., a firm which is now located in Shirley. The Frost company remains a top elastic support resource. Through the years, they absorbed such styles at the Warren Hose Supporter, invented by Andrew Warren in 1888, and the Velvet Grip Supporter in 1892, and more recently the President Suspender Company which began suspender making in 1872. Frost is now New England's largest producer of men's and boys' belts.

There are more than 400 firms producing women's, misses', junior and girls' wear in Massachusetts. In size and scope the industry is larger than its male counterpart, employing some 10,000 workers in the Greater Boston area alone and ranking third nationally. Although Massachusetts, Boston in particular, is noted for its sportswear production, both in quality and quantity, the market is a highly diversified one, containing three of the largest dress manufacturers in the world, and outstanding producers of coats, maternity, bridal, underwear, and children's apparel.

In the early 1900's Massachusetts was second to New York in the production of cloaks and suits, and a natural extension of these activities was the manufacture of skirts. The first skirts were extremely long garments with trains. Sizing was a major problem because the female shape was continually changing. A woman's waist used to be about 15 inches narrower than her hips because of tightly confining bone corsets. Today the difference between waist and hips is approximately 10 inches. Skirts were virtually hand-made with the bottoms bound with velvet and hand-pressed. The garments were so completely finished on each side that they could be reversed and worn.

Many of the present-day sportswear manufacturers have a touch of the early firms in their background, most notably from two Boston companies. the Columbia Skirt Co. and the F & M Skirt Co.

Sportswear is a natural development of the 20th century. As women gained their independence and assumed a more important role in the business, political, and social world, their clothing needs shifted towards more flexible and casual attire. The two World Wars and the subsequent migration to suburban living also contributed to the sportswear movement, with the acceptance of slacks and two and three-piece outfits. The first sportswear selections were skirts and blouses. These have since been expanded to include several types of pants (bermudas, toreadors, pedal pushers, etc.), culottes, sweaters, and various dress forms.

Massachusetts sportswear is a $100 million industry. Some of the leaders are Century Sportswear Co., Inc., Rosecrest Inc., Collegetown Sportswear, Madison Sportswear Co., and Personal Sportswear, Inc., all in the Greater Boston area. Davis Sportswear of Brockton is another leader.

Nearly a $45 million volume is attributed to the state's three leading dress manufacturers; Puritan Fashion Corp., Waltham, Kay Windsor Inc., New Bedford, and Berkshire Frocks, Inc., Boston. The latter firm specializes in sizing and styling for both women and misses 5'5" and under, and this firm has been instrumental in catering to women of special size. One of the oldest Boston dress houses is S. Bloom & Sons. This company is noted for its size diversity, with garments up to size 56.

Two girls' and children's apparel resources of considerable size are Girltown Inc., located in South Boston, and the Rainbow Girl Coat Company of Springfield. Additional women's coat sources are Trencher Inc., Springfield, and Ken-Whitmore, Inc. in Pittsfield.

The William Carter Company, headquartered in Needham, recently marked its 100th anniversary as a leading producer of underwear for the entire family, and infants' and children's outerwear and sleepwear.

The range of the apparel industry can best be demonstrated by its prominence in specialty markets such as bridal, maternity, millinery, and lingerie. Boston is the home of three internationally famous bridal concerns: House of Bianchi, Inc., Phillipa Gowns, Inc., and Priscilla of Boston, Inc.

Boston Royal Petticoat Co. is credited with being among the first to introduce maternity apparel and lingerie, and is one of the four largest apparel companies in the state. The others are Stern-Made Dress Co., Inc., M. H. Fine Co., and the Fitwell Dress Company. In the lingerie and undergarment field important sources are Chicopee Undergarment Corp. of Chicopee, I. Schneierson & Sons Inc. of Fall River, States Nitewear Mfg. Co., Inc. of New Bedford, and Goddess Bra Co., Inc. of Cambridge.

Large millinery employers in Massachusetts are the Framingham Hat Corp. of Framingham, Kartiganer Hat Corp. of Upton, and Winfield Hats, Inc. of Holyoke. Merrimac Hat Co., Inc. of Amesbury is a major resource for fur felt hat bodies.

Massachusetts manufactured $22,680,000 worth of knit goods during 1963. For the same year the industry employed 2,571 workers in some 30 firms. Early knitwear centered around Winchendon, Malden, Chelsea, and East Boston. The varsity or award sweater re-

Specialized sewing operations by skilled women stitch the component parts together into the finished garment.

ceived its impetus from Massachusetts knitters as did the popular snap button jersey and the cricket sweater. In 1865, the Otis Company imported workers from Nottingham, England, to establish stocking manufacturing at Ware. One hundred years later, cotton knitting continues at the same location. However, the product has evolved from stockings to underwear and now to outerwear, and the present manufacturer is Ware Knitters, Inc.

Dominant in the industry are Garland Knitting Mills, Brockton, Revere Knitting Mills, Wakefield, Worcester Knitting Co., Worcester, Bristol Knitting Mills, Fall River, F. R. Knitting Mills, Fall River, Malden Knitting Mills, Malden, M. K. M. Hosiery Mills, Leicester, and Suffolk Knitting Co., Lowell. It is indicative of the industry's diversity that the prime Massachusetts suppliers are located in widely scattered areas and have a production range which includes sweaters, shirts, swimwear, and outerwear for the family.

Allied with the apparel industry because of similar production and marketing techniques are various soft good lines such as curtains and draperies, home furnishings, canvas bags and apparel findings, and other related products. There are approximately fifty-five curtain and drapery manufacturers in Massachusetts; among the largest are Cameo Curtain of New Bedford, Inc. and Louis Hand, Inc. of Fall River.

In the home furnishings field Vatco Mfg. Co., Inc. of Boston produces furniture slip covers. Wm. Wright & Sons Co. of Warren is one of the nation's biggest resources for tapes, braids, trimmings, and ribbons.

Apparel manufacturers generally "cut-a-line" three months in advance of a season. These samples are then given to salesmen and are shown to retailers through personal visits and trade shows. All but the very small maintain showroom space in New York City where the bulk of purchases for chain and large department stores are made.

The apparel industry in Massachusetts employs 56,853 workers with a payroll of $192,842,000. The value of the finished product totals $322,193,000. Employment is divided into three groups: women's, misses', and children's, 27,920; men's, youth and boys', 11,114; other apparel, 13,654.

The four largest apparel producing areas in the state are Boston with 21,200 workers, Fall River with 12,300, New Bedford with 7,900, and Springfield-Holyoke with 4,933.

Today, nearly a thousand industries across the state are engaged in the tailoring of fabrics of all kinds into personal, home and business needs. A style-conscious world is aware of trade-names on hundreds of Massachusetts cloth products.

Specially designed equipment can save production time as in this machine attaching zipper stops.

Final pressing and inspection of garment before careful packaging and shipping to retailer.

The Shoe and Leather Industry

America's first Shoemaker establishes Massachusetts as the leader

Massachusetts, the birthplace of the shoe and leather industries in America, remains to this day the leading shoe state in the nation. This leadership is based on both shipments and product value, as well as on employment. The shoe and leather industry has been a dynamic industry from its founding in Salem in 1629, through the industrial revolution and machine developments in the decades after the Civil War and the continued progress of more recent years in machinery, methods, and materials which resulted in today's highly mechanized, modern industry.

Footwear was one of man's earliest creations. Early man made shoes long before he made records of what he thought or did. He made shoes as a protection against the elements—against hot sand, cold weather and ice, rough stones, and the like.

The first known form of footwear was the sandal. Earliest pictures of ancient Egyptian sandals, in 1495 B.C., show simple sandals made of pieces of hide sewed together and held to the foot by leather cords. Similar sandals are still worn in warm countries of Asia, Africa, and South America.

In early days, shoes showed the rank of wealth of the wearer. This was true among the early Egyptians and later among the Greeks and Romans. High laced sandals made of leather carried Roman soldiers on to world conquests.

New types of footwear were developed as finer leathers were tanned and early shoemakers improved their craftsmanship. In the 1300's, a shoe called the crackowe or poulaine had a pointed toe so long that it had to be held up by a chain so the wearer could walk. In the reign of Queen Mary of England, the duckbill shoe was so wide that a law had to be passed limiting the width of its toe to 6 inches. Currently, duckbill shoes with extra wide toes are again popular in England.

Throughout the Middle Ages, footwear became one of the most important articles of dress, and the height of the boot varied according to the social or political standing of the person wearing it. A prince would wear a boot 30 inches high, a baron would wear boots 20 inches high and a knight, a boot 18 inches high, etc. These differences may have been due largely to the price the wearer could afford to pay for materials, workmanship, and ornamentation.

In the 1600's, heavy jack boots with large cufflike tops were worn by English soldiers. In the 1600's, leather slippers with high tapered heels were first worn by French women. This style feature continues today in women's shoes.

From the 1800's until World War I, many women and most men wore high shoes. Women's high shoes often covered their legs from the ankles to mid-calf height and were sometimes even higher. The low dress shoes worn by everyone today displaced high shoes for general wear in the Twenties. This has remained a basic style ever since.

Shoe styles, like all fashions, have their cycles of popularity. The boots so popular today for both women and men were just as popular at the turn of the century, although of a different type.

From the earliest days to the middle 1800's, sandals and shoes were largely made by hand. Shoemakers used practically the same tools throughout the ages.

These included a lapstone and hammer for preparing the leathers. Also, a knife for cutting the upper and sole leather, an awl to bore holes, pliers and needles for sewing were used.

During Colonial days, and until the middle of the eighteenth century, it was common practice for itinerate shoemakers to travel from village to village and from house to house making and repairing shoes. In the early nineteenth century, shoemakers in America worked in small shops called "ten-footers" because they measured ten feet on each side. There the shoemakers worked at a bench, holding the shoes between their knees. They were assisted by apprentices. These "ten-footers" represent the first known division of labor and were the first step toward the modern factory system. One of these "ten-footers" was owned and operated by Henry Wilson, who later became Vice President of the United States.

The first shoemaker in America was Thomas Beard, who came from England with a supply of upper and sole leathers, and settled in Salem, Massachusetts, in 1629. In 1635 Philip Kirtland founded the shoe industry in Lynn, which grew to become the nation's greatest shoemaking center during the 18th-19th century.

These men were followed by many others, who tanned the leathers and made shoes for a growing nation.

Through the entire history of man, up to the age of mechanization, in the middle 1800's, shoes were made in few sizes and with fewer widths. All too often, little care was given to having them fit properly. Most shoes were made "straight"; that is, there was no such thing as a right or left shoe. For many years, American shoe manufacturers have been acknowledged as outstanding producers of better fitting and more comfortable shoes. To this day in Europe, many shoes are made in only one width.

From 1850 on, more and more machines were introduced in America. These were later used or copied in virtually all modern countries in the world. The first sewing machine was invented in 1844 by Elias Howe, a Massachusetts inventor. In 1858, Lyman Blake, a youthful Massachusetts machinist from Abington, secured the first patent on his machine devised for sewing shoe uppers to soles. Later given the name of its financial promoter, Colonel Gordon McKay, this machine became the first and most important of many, and marked the beginning of the mechanical age in the shoe industry.

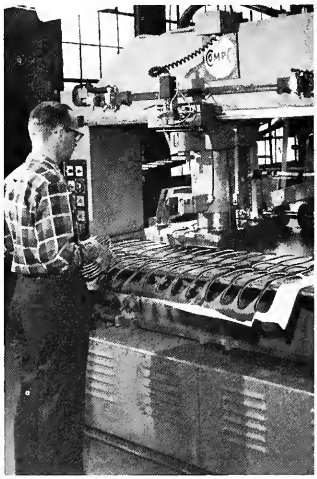
In 1869, the next major invention came. It was the Goodyear welt sewing machine, and greatly improved models with some of Goodyear's basic principles are used today in producing fine men's welt dress shoes. This machine sews welting to the upper and insole in preparation for attachment of the sole.

These sewing and stitching machines were followed in the 1870's by the introduction of a group of machines to trim the edges and heels of shoes. Later lasting and pulling over, or forming, machines were invented. These were all designed to increase the productivity of the worker, i.e. to increase the number of pairs of shoes each operator could produce in a given period, either in an hour, or in a day.

In more recent days, a major development occurred in the 1920's with the commercial development of equipment, adhesives, and techniques for the manufacture of shoes by the cemented process in Boston. Although invented in Germany, these machines did not prove practical for mass production techniques until William H. Bresnahan, a Lynn shoe manufacturer, further developed this machine by perfecting a satisfactory adhesive for attaching shoe soles to uppers.

Bresnahan founded an important shoe machinery company, Compo Shoe Machinery Corporation, in 1928. This company has continued its developments of other cementing equipment, especially newer and better adhesives. It continues to operate in a large modern plant in Waltham. In recent years, Compo's International Vulcanizing Corporation Division has successfully introduced the most fully automatic shoemaking equipment in the form of a single machine on which the upper portion of a shoe is completely formed and the sole or bottom portion is created and bonded to the

A fitting room automatic transporter moves components to operators as needed.



Three layers of material are sealed and cut in a continuous operation to form shoe innersoles.

upper portion, with the shoe coming off the machine in finished form.

The world's largest shoe machinery company is the United Shoe Machinery Corporation, with main offices in Boston. It was founded in 1899 with the consolidation of the three leading non-competing shoe machinery manufacturers of that era: Goodyear and McKay Machinery Companies and the Consolidated Lasting Machine Company. The owners of these companies joined forces to provide a more complete line of equipment and to improve their service to the shoe industry.

The principal USM manufacturing plant in Beverly is a quarter of a mile long with a million square feet of floor space, or the size of more than 18 football fields. There, it not only produces shoe machines, but also maintains the most extensive research laboratories to develop shoe machinery found anywhere in the world.

This company maintains branch plants in every continent and in over 26 major countries. In the past decade, it has broadly diversified, and now produces machines and supplies for many other industries, as well.

The second largest shoe machinery company is International Shoe Machine Corporation, in Boston. It was founded in 1938 by J. S. Kamborian, inventor of the first Cement Lasting Machine, and the Semiautomatic Toe Lasting Machines, covered by many patents. More recently, this company invented and is marketing a complete Lasting Room utilizing three machines, all using only adhesives for lasting under the Therma-lasting Process also developed by International.

Scores of other small, specialized shoe machinery companies are operating in Massachusetts. In addition, a number of management consultant firms are available to assist shoe producers in this state.

Hundreds of firms, a few very large but most of small size, operate in producing the scores of items that go into shoemaking. These start, of necessity, with the last. This is a wooden or plastic form over which a shoe is produced.

All types and finishes of leathers, calf and kip, side upper leathers made from cattlehides, kid leathers from goatskins, sheepskins, snake and reptile leathers, are tanned and sold in Massachusetts. Today, this state is the largest leather producing state in the nation.

Massachusetts' leather tanning and finishing industry in 1963, the latest year for which official government data has been reported, had 162 establishments with total employment of 5,994. These workers were paid wages totaling $32,000,000 that year. The value of products shipped from their plants amounted to $174,973,000. These totals are not too different from those estimated for 1965! Much of the leather which goes into Massachusetts-made shoes is produced right in the Bay State.

Tanning of leather is one of the state's oldest industries. As early as 1623, the first tanner, Experience Miller, landed on our shores at Plymouth. In the early days, the bark of oak trees provided the principal tanning material with which to preserve hides. The bark was first pulverized by being crushed under heavy stones, then it was sprinkled between layers of skins in a vat. Water was then poured into the vat and the hides were kept in the solution for six months or more. Today, with many other tanning agents available, and more modern equipment, the process is much faster and the results more satisfactory.

An invention of a Massachusetts man was instrumental in spurring the development of the leather industry. Samuel Parker of Newburyport in 1809 obtained a patent for a machine which could split leather to any thickness. This made it possible to obtain from a single hide two pieces of leather instead of one, the "grain split" from the outside of the hide and the "flesh split" from the inside. Splitting not only doubled the footage of leather but it also provided leather which was more adaptable for specific purposes.

Peabody is a center for the tanning industry in the state and calls itself "the Leather City." There are some 75 manufacturing firms in the city connected with the leather industry. About three out of four of the city's industrial workers are employed by these companies.

Located in Peabody is the home plant of the A. C. Lawrence Leather Company, by far the largest tannery in the state, whose employment totals about 1,500 persons. Actually, it operates, in that city, three separate tanneries, making calf leathers, sheepskins, and cowhide leathers respectively, and also a patent leather finishing plant. The leathers made go into many different end products, including shoes, garments, and gloves, and are shipped not only to all parts of the United States but also to many foreign countries. The company is a division of Swift & Company.

In several communities adjacent to Peabody, particularly in Salem, Lynn, and Danvers, there are also a large number of leather tanning and leather finishing concerns. Among the larger tanneries on the North Shore are included John Flynn & Sons, Inc. and Hawthorne Tanners, Inc. both of Salem; Verza Tanning Co., Peabody; Creese & Cook Co., Danvers; Benz Kid Company, Lynn

and John J. Riley Company, Woburn. In Haverhill are several tanneries with the largest being L. H. Hamel Leather Co. Nor is the production of leather wholly confined to this area. There are a number of tanneries in Boston, and one of the largest, Geilich Tanning Company, is located in Taunton.

In addition to the production of leather for shoes, Massachusetts tanneries make types of leather which are widely used in the manufacture of gloves, handbags, and leather garments. Popularity of leather garments has increased markedly in recent years both in this country and abroad.

Buxton Inc., established at the turn of the century in a small shop in the home of Mr. and Mrs. Dana Buxton in Springfield, is nationally famous as manufacturers of key cases, billfolds, and leather accessories. The company is now quartered in a modern plant in Agawam and has a branch plant in Attleboro where it manufactures leather jewel cases.

At Bridgewater is the George O. Jenkins Company, one of the largest manufacturers in the country of leather fiber materials. The fiber products, made from waste leather, are sold largely to the shoe industry. The biggest item is "heeling board," from which heels for both men's and women's shoes are made. The company also makes a mid-soling material used between the uppers and soles of men's shoes. Other products are leather fiber gaskets and leather fiber dust guards for the journal boxes of railroad cars.

Other major shoe materials are fabrics and plastics of many kinds used for shoe uppers and for linings.

For soles, leather, rubber, and man-made materials are all used in varying quantities and are constantly being improved in appearance and wearing qualities. For heels, wood, rubber, plastic, aluminum, and other metals are all used. Also leatherboard and fibreboard are used extensively for making built-up heels.

Numerous construction materials used in producing shoes include box toes, counters, toplifts, steel shanks, and welting, all of which are produced in Massachusetts.

Preliminary treatment of leather requires careful vacuum drying.

The newest and most widely publicized shoe material is Corfam by duPont. This is an important material for the future development of automation in the shoe industry.

In Massachusetts, the footwear, except rubber, industry is one of its largest industries. In 1963, the latest year for which U.S. Bureau of the Census data has been published, 194 shoe establishments reported total employment of 35,182 workers, who were paid wages amounting to $134,772,000. The value of all shoe and slipper shipments that year, at factory prices, totaled $367,459,000. This represented shipments of 84,860,000 pairs, or 14 per cent of total United States shipments of 600,813,000 pairs that year.

With almost 200 producers, it is not feasible to list all the individual companies by name. Rather, it is more significant to highlight a few and to note the major shoe centers in the state.

Haverhill, known as the "Queen Shoe City of the World," is the largest shoe community in the Commonwealth. It is noted as a leading women's fashion shoe center and is the location of the oldest women's shoe manufacturer in the Commonwealth, Hartman Shoe Mfg. Co., organized in 1911. Nearby cities of Lawrence and Lowell, as well as Lynn, Salem, and Beverly on the North Shore, are also important centers for women's footwear.

Prominent among the large producers of women's shoes are Dori Shoe Co., Inc., Lynn, Genesco, Inc. with factories in Lawrence and Brookfield, Ornsteen Shoe Co., Inc., Haverhill and A. Sandler Co., Inc. of Boston which operates six plants in New England, three of which

are in Massachusetts. Blue Bonnet Shoe Co. of Lawrence specializes in children's shoes.

Brockton, including surrounding cities and towns on the South Shore, is the center for the production of men's shoes. Here plants are still producing some of the oldest and best known brand name shoes in the country, some household by-words for 50 to 100 years. Brockton Footwear, Inc. manufactures world-famous "Foot Joy" golf shoes and men's dress shoes. Knapp Bros. Shoe Mfg. Corp. produces men's dress and work shoes, and is the largest door-to-door shoe distributor in America. Stacy-Adams Company is a manufacturer of men's high quality shoes under the brand name "Stacy-Adams." The company was established in 1875 and has continuously produced men's shoes of highest quality since that time. In 1963 the company embarked on an expansion and modernization program, and its plant is presently one of the most modern shoe factories in Massachusetts.

Rockland is the home of E. T. Wright & Co. Inc., manufacturers of the popular "Wright Arch Preserver" shoes. Stetson Shoe Company of South Weymouth produces the well-known "Stetson" and "Banister" high grade men's shoes, and in Whitman, "Bostonian" shoes are made by the Commonwealth Shoe and Leather Company. In Bridgewater the John E. Lucey Co., Inc. produces men's dress shoes; in Middleboro the Plymouth Shoe Co. manufactures both men's dress shoes and hand sewn moccasins; Porter Shoe Co., Inc. produces both men's and boys' shoes in Milford and Joseph F. Corcoran, Inc. of Stoughton produces men's welt shoes. Men's heavier work shoes are produced in Worcester, in Fitchburg, and in Hudson.

Finally, Boston is noted as a famous shoe center. This is primarily because it is the home of The Green Shoe Manufacturing Company, maker of "Stride Rite" children's shoes. These shoes are produced in an ultramodern plant one full city block in size, the largest under one roof in the country. Boston is also the home of two other nationally known concerns, one being the Consolidated National Shoe Corporation. This company is one of the largest shoe companies in the state and produces women's shoes in factories located in Ware and Webster, and children's shoes in Lawrence. This company also operates two other factories in Maine and one in New Hampshire. The other concern in Boston is French, Shriner & Urner Mfg. Co., manufacturers of the famous "French Shriner" and "Edwin Clapp" men's high quality shoes. Everett is the home of Eagle Shoe Mfg. Co. Inc., a large manufacturer of men's and boys' shoes.

Specialty type shoes are also made in abundance in Massachusetts. For example, one of the largest manufacturers of athletic shoes in the eastern United States is in Cambridge: A. R. Hyde and Sons Co. The oldest shoe company in the state, B. A. Corbin & Son Co. of Marlboro, founded in 1831, is still producing its line of "Spalding" casual shoes. Ice skate outfits are made in Ware by the Athletic Shoe Division of Brunswick Sport Products Co. In Marlboro, the century-old John A. Frye Shoe Company is located. It is a specialty leather bootmaker whose products include cowboy boots, riding and hiking boots, and a wide variety of pull-on type, all-purpose boots. The nation's largest producer of babies' and infants' shoes is Mrs. Day's Ideal Baby Shoe Company of Danvers. The largest work shoe manufacturer in Massachusetts is the H. H. Brown Shoe Co., Inc. of Worcester. In contrast, Matinee, Inc. of Lynn and its affiliated company, National Ballet Makers, Inc. of Boston, both produce world-famous "Capezio" sandals and dance footwear. Also in Lynn, the highest priced women's shoes produced in Massachusetts are made by Schwartz & Benjamin, Inc. In Wakefield, L. B. Evans Son Company, incorporated in 1841, is the oldest continuously operating shoe company under the same

Operators attach a tape rib to shoe inner-soles which will later be sewed to the welt.

family management in the United States and still manufactures the famous "Evans" hand-turned men's slippers.

Other communities where shoes are produced include Webster, where sports and casual type loafers are made by Bates Shoe Company; North Adams, where men's dress shoes are made by Wall-Streeter Shoe Company; Marlboro, whose four shoe firms include Diamond Shoe Corporation; and Wakefield, whose largest women's shoe producer is the Copley Shoe Company.

Massachusetts is also the home of a very important rubber footwear industry. In relatively few but very large companies, millions of pairs of canvas sneakers, rubbers, rubber shoes, and overshoes are manufactured by the vulcanization process, and are described in the rubber and plastics chapter.

Marketing of footwear, both leather and rubber types, is accomplished in many ways. Shoes are made in more than 300 sizes and widths, on over 10,000 different last shapes or styles.

The majority of factories produce shoes only to order. Selling is done through jobbers, chain stores, department stores, or directly to retail stores.

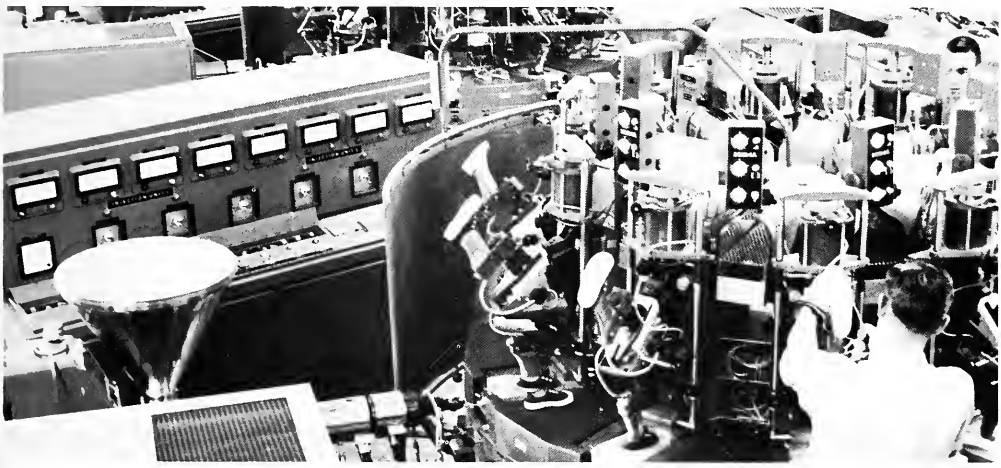
However, other shoe manufacturers, particularly those producing branded shoes, maintain complete in-stock departments, where customers' orders are shipped upon receipt. Some of these manufacturers own their own stores, and distribute only their own brand-name shoes.

One man, with a single associate, established the shoe industry in Massachusetts in 1629. Wooed from England with a guarantee of 10 pounds per year, he became, in Salem, the first skilled shoemaker.

For many years the manufacture of shoes was to continue by the same laborious hand process. Not until the 1800's did inventive minds produce machine tools that were to revolutionize the entire industry. By combining forces, the Massachusetts shoe industry and Massachusetts machine tool industry profited equally and established the Commonwealth as a leader in shoe production.

Leather producers, locating near their prospective customers, rapidly increased in number, as did other manufacturers of boot and shoe components. Makers of luggage, handbags, and personal leather goods, finding here a ready source for raw material, invested capital in manufacturing plants.

Today, the Massachusetts shoe, leather, and allied products industry is the fourth largest industry in terms of employment, with some 49,700 employees who earn each year nearly $200 million in salaries and wages as they produce goods worth over $640 million annually which represents a value added by manufacture of $311,639,000.



Injection molding machines automatically mold and attach soles to footwear.

The Furniture Industry

Maintaining a heritage — keeping pace with custom

According to some historians, civilization and the chair are the same age. It is believed that when early man took time to sit at meals instead of grabbing from the communal pot he found repose sitting, instead of sprawling on the ground. Thus, he became apart from the beasts.

The chair, basic unit of furniture, was used by the ancient Chinese. It has also been found in the tombs of early Egyptians. These chairs were comfortable and well designed. Their descent through the ages took the form of thrones and seats for nobility. The common man became acquainted with chairs in the fifteenth century. The Pilgrims, both in Holland and in England, were accustomed to stools which were the first furniture made in Massachusetts. Every shipload from the Old World to the Bay State numbered a cooper among its passengers. In many cases these barrel-makers were also journeyman cabinetmakers. One of these was John Alden, who was told to "Speak for yourself, John," when he advanced the suit of Myles Standish for the heart of Priscilla Mullen. Although a skilled artisan, Alden seems to have devoted his talents to making chairs for contemporary church and state dignitaries.

Massachusetts, blessed with an influx of skilled workmen, and having an abundance of first growth hardwood trees, became an early leader in the production of chairs and other articles of furniture. But public taste, good or bad, dictates the type of furniture made. For this reason, Grand Rapids, Michigan became a style leader in the last half of the last century. Nearly a half century ago. a half dozen excellent magazines dedicated to the beautification of the American home were born. These had a tremendous influence on the furniture trade, and took a strong stand for colonial reproductions. They resulted in the influx of trestle tables, hutch cabinets, low and high boys, Governor Winthrop desks, and four poster beds.

Colonial furniture was crude. It was hacked out of green wood by unskilled men with inadequate, dull tools. It is easy to see, therefore, why the well-made reproductions caught the public fancy. Today Massachusetts has 350 furniture factories, which produce a wide variety of home, school and office furniture.

Gardner, Chair City of the World, employs the majority of its work force in the furniture trade, mostly in the manufacture of colonial reproductions. At the eastern entrance to Gardner, a Paul Bunyan size ladderback chair sits. It tells the story of the city's industrial endeavors. In one year during the Twenties, Gardner factories produced a total of four million chairs. Most of these chairs were made entirely in Gardner and were fashioned from rock maple and yellow birch. Many were made of separate parts produced elsewhere and assembled in the Chair City. Factory owners annually made a tour of small turning mills, located off the main roads, in the heart of the woodcutting areas. At these mills, trees were processed into semi-finished lumber. Sections of this lumber were turned on a lathe to produce inexpensively a finished or "turned" leg. One man is reported to have bought a million of these turned legs for a cent each from a financially hard-pressed mill. This illustrates the purchase power of $10,000 forty years ago.

Massacbusetts, once the leader of the nation in furniture production, now ranks twelfth with just under 12,000 employees, annual payroll of $52 million, and value added equal to $86,343,000. A variety of reasons have effected this change, such as higher transportation costs, changing consumer tastes, and foreign and domestic competition. The South and Midwest now have much of this industry, due at least in part to competitive advantages of lower taxation and labor costs.

Gardner firms began manufacturing chairs as early as 1805. Today some of the best known companies are still operated by descendants of the founding families. These companies include Heywood-Wakefield Company, Nichols & Stone Company, S. Bent & Bros., Inc., and Conant Ball Company. Diversification of product and change in markets have decreased employment at some of the plants. Heywood-Wakefield once employed 1,600 men and women in Gardner. Today's total is about 1,000. Over the years since 1826, this company had added auditorium, theatre, church, bus, and railroad seating, as well as a line of tubular school furniture with "HeyWoodite" solid plastic seats, backs, and desk tops

for greater durability, to its basic solid wood household furniture lines. Today only the solid wood household lines are made in Gardner; the other products are manufactured in plants in Newport, Tennessee; Menominee, Michigan; and Orillia, Ontario, Canada.

The addition of rattan and reed products in 1874 brought the Heywood Company in competition with the Wakefield Rattan Company in Wakefield, Massachusetts. The latter firm was started by Cyrus Wakefield who watched bundles of rattan, used as ballast on clipper ships for small but precious cargo, discarded as worthless on Boston wharves. Wakefield developed a method of splitting the rattan and weaving the resulting cane, first by hand and then by machine. Competition ended between these two firms when they merged in 1897. The drive and genius of Levi Heywood were tremendous factors in the firm's growth and success, according to the firm's president for the past thirty-five years, Richard N. Greenwood, Heywood's great-grandson.

Conant Ball, like Heywood-Wakefield, in business for more than a century, has a line of "Roger Conant" colonial reproductions. This line was named for the colonist who founded Salem and was an ancestor of the Gardner Conants. Charles C. Brooks, Jr., current president, is an 11th generation descendant of the Witch City founder.

Nichols & Stone, founded as a chair factory in 1857, has confined its production exclusively to chairs. For the past half century, it has further confined production to the reproduction of Windsor and other early American chairs. It calls itself the Home of Windsor chairs. Many of these have rush seats made from cat-o'-nine-tails cut in the Finger Lakes district of New York.

Nichols & Stone and another long-established Gardner firm, S. Bent & Bros., Inc., make many of the so-called "Alumni" chairs which are popular with college graduates. These are Windsor-type chairs with the seal of the college on the back of the chair.

Gem Industries, formerly known as the Gem Crib and Cradle Company and established in 1911, is one of Gardner's largest employers. They have an extensive and diversified line of products, manufactured by four major divisions. The Baby Land Division is a leader in juvenile furniture (cribs, chests, bassinets, and play pens). The Metal Division produces spring construction for beds and sofas and is the largest single producer of juvenile furniture hardware in the country. The Proctor Division specializes in dormitory and institutional furniture, both built-in and free standing. The Mohawk Division has one of the most modern production lines for hardwood dimension and glued-up panels for the furniture industry. The company also operates plants in Broadalbin, New York, and Weyauwega, Wisconsin.

Other large furniture producers in Gardner include Thayer, Inc., which for over a quarter of a century has been generally recognized as the largest producer of a complete line of related juvenile products in

Assembly of finished parts requires complete exactitude to achieve the flowing lines of the original design.

Smooth edge contours on wooden furniture require a craftsman's control.

the country, including nursery furniture, carriages, strollers, high chairs, play pens, travel beds and seats, walkers, bouncers, nursery chairs, rockers, mattresses, and padded goods; Custom & Modern Upholstering Company which makes chaise lounges, boudoir chairs, and early American living room and old Cape Cod styled chairs and rockers; L & Z Kamman Company, chairs, tables, and rockers; O'Hearn Manufacturing Company, colonial furniture; C. H. Hartshorn Inc., upholstered living room furniture, dinette sets, chairs, rockers, and settees; Kelly Bros. Inc., sofa beds, davenports, and tables; and Rousseau Bros. Manufacturing Company, boudoir chairs and chaise lounges. Gardner is also the home of a number of smaller companies which over the years have established enviable reputations for the production of high-quality furniture.

Although President Kennedy's famous rocking chair was not of Massachusetts manufacture, the publicity about the late President's chair resulted in a sharp spurt in sales of rockers all over the country. The sudden public demand for rockers was a bonanza to manufacturers of this type of chair.

Although some Massachusetts upholstered furniture is produced in Gardner, most of it is manufactured in other cities, with the heaviest concentration in the Boston area where there are some forty firms in this field. A Cambridge firm, Irving & Casson, is one of the largest manufacturers of custom-built wood office furniture in the country. It recently built all the chairs used in the Massachusetts House of Representatives. These chairs were installed to replace the originals built by this same company for this chamber in 1897. It built the furniture originally installed in the United Nations Building in New York, except for a few imported pieces. Also, it has recently replaced this furniture when changes in the arrangement of the building necessitated use of a different type of furniture. For many years it has built the official Governor's Chair for most of Massachusetts' Governors. Each chair has the seal of the Commonwealth carved on its back.

Irving & Casson has made pews, pulpits, and carvings for many famous cathedrals, including St. John the Divine in New York, the Washington Cathedral, and the National Shrine in Washington, as well as furniture for some of the outstanding libraries in this country.

Selig Manufacturing Co., Inc., one of the nation's leading manufacturers of upholstered furniture, has recently moved into a new million-dollar plant in Leominster. In this modern one-story building, providing 140,000 square feet of floor space, it has combined its Massachusetts operations, formerly conducted in Fitchburg and Leominster. The company, founded in 1931 by two Massachusetts men, M. M. Selig and Samuel H. Wexler, specializes in contemporary and modern furniture, and is the largest manufacturer in the country in its specialty. Selig also operates plants in Louisiana, North Carolina, and California.

A nationally and internationally known producer of contemporary-type furniture is Harvey Probber, Inc., whose Fall River plant produces residential, office, and contract furniture, particularly for bank lobbies and business offices. The president of the company, Harvey Probber, himself designs many of the company's products. The firm manufactures both wood and metal furniture, and many of its items combine the two. Some furniture of Probber design is supported by legs having a steel core to which a thin casing of solid wood is bonded. One piece in which the firm takes pride is an executive desk made especially for the Austin, Texas office of President Lyndon B. Johnson.

Wakefield Industries, Inc., started only about ten years ago in Wakefield, has had a meteoric rise. It is now the leading producer of wood portable phonograph cabinets in the country and it employs about 350 persons. About eight years ago, when the Wakefield plant became inadequate, it was moved to Lowell. Here cabinets are made of solid Ponderosa pine or of plywood covered with a veneer. This company has contracts with several of the nation's leading manufacturers of phonographs.

Exquisite reproductions of 18th Century furniture masterpieces are made by the Kaplan Furniture Company of Medford. The firm's famous Beacon Hill Collection contains authentic reproductions of some of the choicest work of designers and cabinetmakers in England, America, the Continent, and the Orient, together with modernized versions of some of these styles.

Manufacture of this fine furniture is largely a hand operation, performed by some 100 skilled workers at the Medford factory. The furniture is sold through interior decorators and selected department stores across the country. Pieces produced by the Medford firm have been purchased for some of the finest hotels and public buildings. During the Truman Administration, the firm made a number of pieces for the White House.

Simon Kaplan, president of the firm, is a son of the founder, Isaac Kaplan, who started the business with the modest announcement: "Late from London—Wood Turner and Carver—Cabinetmaking as fine

as can be had in England." Another son of the founder, Leon Kaplan, is the firm's designer. Isaac Kaplan's skill in making furniture and in restoring old chairs, tables, and chests soon attracted to his shop a large volume of business from owners of stately mansions on Boston's Beacon Hill. The Beacon Hill Collection had its beginning in a pair of tip tables which he designed.

Temple-Stuart Company, with plants in Templeton and Winchendon, is a large producer of dinette suites and dining room furniture.

Scattered about the state are several other sizable manufacturers of furniture. These include Charlton Company, Fitchburg, living room furniture; Dudley Manufacturing Corporation, Webster, upholstered living room furniture; Winchendon Furniture Company, Winchendon, household furniture; Plycraft Inc., Lawrence, molded plywood chairs; Whitney Mfg. Co. of South Ashburnham, chairs and tables; Level of Winchendon, Division of Mason & Parker Mfg. Co., restaurant seating equipment; and Walpole Woodworkers, Walpole, whose outdoor furniture is made mostly of cedar.

Historically a manufacturer of bicycles, the Columbia Manufacturing Company of Westfield began the production of school furniture in the early 1950's. It was a natural diversification for Columbia because the same equipment used to fashion tubular metal into bicycles can be used to make chair legs and bases for desks. Columbia's metal framed desks and chairs are offered with tops, seats, and backs of a tough plastic wood-flour compound material made by the C. F. Church Division of American-Standard, whose plant is located in central Massachusetts in the town of Monson.

Of the twenty-three firms in Massachusetts making metal household furniture, the two largest are Hampden Specialty Products Corporation of Easthampton, which makes metal folding furniture, bridge furniture, and outdoor furniture, and Prest-Wheel, Inc. of Grafton, which makes aluminum outdoor furniture. Among the products of some of the smaller firms are: juvenile furniture, metal kitchen equipment, dinettes in wrought iron and chrome, metal wardrobes, TV tables, and aluminum outdoor furniture.

There are more than fifty firms in Massachusetts making mattresses and bedsprings. Among the larger ones are Simmons Company, Medford, bedding; Rose-Derry Company of Newton which produces mattress and box springs, crib mattresses, pads, car seats, and car beds; and Webster Spring Company, in Oxford, springs for the furniture and bedding industries.

Production of fixtures for commercial establishments, one phase of furniture-making, is an industry in itself.

One of the largest companies in the field is Maintain Store Engineering Service, Inc., which manufactures a complete line of store fixtures. The name of the latter company causes some confusion, because people think that the name "Maintain" indicates that it is a maintenance concern rather than a manufacturer. Actually the company gets its name from the name of its president, Mr. Russell E. Maintain.

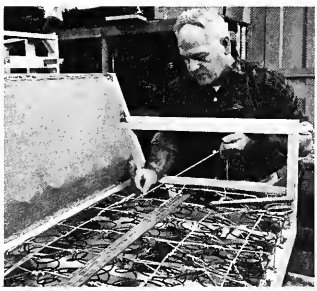
In the metal segment of the fixtures field, there are eight Massachusetts companies with four or more employees. The largest is Andrew Wilson Company of Lawrence which makes steel lockers and steel shelving.

The Frank B. Curry Company in Boston is a well-known firm specializing in restaurant furniture.

Making venetian blinds are some sixteen Massachusetts companies; the largest is Rodney Metals, Inc. of New Bedford, whose consumer division also manufactures a folding floor screen made with wood slats and an aluminum canopy and awning kit for "do-it-yourself" assembly by the purchaser.

Although Massachusetts is not considered a major producer of furniture and related products, this industry has contributed substantially to Massachusetts' reputation as a leading industrial state. The skill of its craftsmen and the Yankee ingenuity of its management have worked together to achieve this enviable result.

Strong joints depend on accurate formation of tenons for precise fit.



Installing a spring seat unit requires an intricate system of hand-tieing each coil.

The Food Industry

An important industry fulfills a vital need

Providing three meals a day, plus a snack now and then for five million people in Massachusetts is big business. Massachusetts residents every day consume some 500,000 gallons of milk and 1,100,000 loaves of bread. On the average they eat about 45,000 gallons of ice cream a day.

Food processors in the Bay State provide the bulk of these items, and they make many other products that go onto the dining tables of Massachusetts residents. Besides what they make for local comsumption, they also produce foods for export to other states, particularly such Massachusetts specialties as seafood, cranberry preparations, and candies.

While dairy products and bakery products account for about half of the total employment of 41,066 persons in food manufacturing in the state, there are other important segments of the industry. These include candy, meat products, canned and frozen foods, and beverages. Employees in the food industry in Massachusetts earn $209,267,000 each year with a value added of $502,039,000.

Among the products made by Bay State food processors are preserves and jellies, salad dressing, pickles, relishes, spices, flavoring extracts, fountain syrups, soft drinks, beer, processed coffee, tea, cocoa, macaroni and spaghetti, potato chips, popcorn, prepared desserts and candy of many varieties.

Historically, Massachusetts has had an important role in the development of modern methods of preparing foods. Back in the 1890's, Samuel C. Prescott and Wm. Lyman Underwood of Massachusetts Institute of Technology made a major contribution to the development of the canning industry when they determined that spoilage of certain lots of canned clams, lobsters, and corn was due to imperfect sterilization.

It was at Gloucester that Clarence Birdseye developed the first successful method of quick-freezing foods. At Gloucester today interesting experiments are being conducted at the new technological laboratory of the United States Bureau of Fisheries. These experiments examine the use of radiation in the preservation of seafoods.

Recently Corn Products Company established a Food Technology Institute in Waltham to study methods of food processing.

While Massachusetts has no fertile plains on which to raise grains, or extensive pasturelands on which to graze beef cattle, the state's location on the Atlantic Coast has provided it with a harvest from the sea that is the basis for one of its most important food products, fish. Fish processing was one of the earliest industries in the state. Soon after their arrival in the new land, Bay State colonists started salting fish which they found in abundance along the coast. The fish found a ready market in England. As early as 1623, the first cargo of salt fish was exported from Gloucester.

Today, the Massachusetts fishing industry ranks third in value and fourth in volume nation-wide, according to the U. S. Bureau of Commercial Fisheries. Landings of fish and seafood at Massachusetts ports in 1964 totaled 409 million pounds plus another 300 million pounds in the form of fish blocks ready for processing. Together their retail value was worth $182 million. Of the total catch, 32 per cent was landed at Gloucester, 31 per cent at New Bedford, 25 per cent at Boston, and 12 per cent at other Massachusetts ports. Gloucester is a leading port for ocean perch and whiting, Boston for haddock, and New Bedford for flounder and sea scallops.

Quick-freeze products, both precooked and raw, account for the major part of this annual volume. Some of the most popular items, such as fish sticks and fish portions, are made from so-called "fish blocks." These are fillets of haddock, cod, whiting, flounder or other varieties which have been packed in a mold and frozen into slabs of uniform size for ease in handling and processing. The blocks of frozen fish can be sawed like lumber to get the desired uniform size for sticks and portions.

Although Massachusetts fishermen provide the catch for some of the fish blocks, a large proportion of the blocks are brought to Bay State processors by fishermen from Canada, Denmark, Iceland, and Norway.

Massachusetts fish products are distributed to all parts of the country. One large processing firm markets about 20 per cent of its entire output on the West Coast. There is a constant parade of refrigerated trucks carrying frozen haddock, cod, whiting, flounder, sea perch, and scallops from Bay

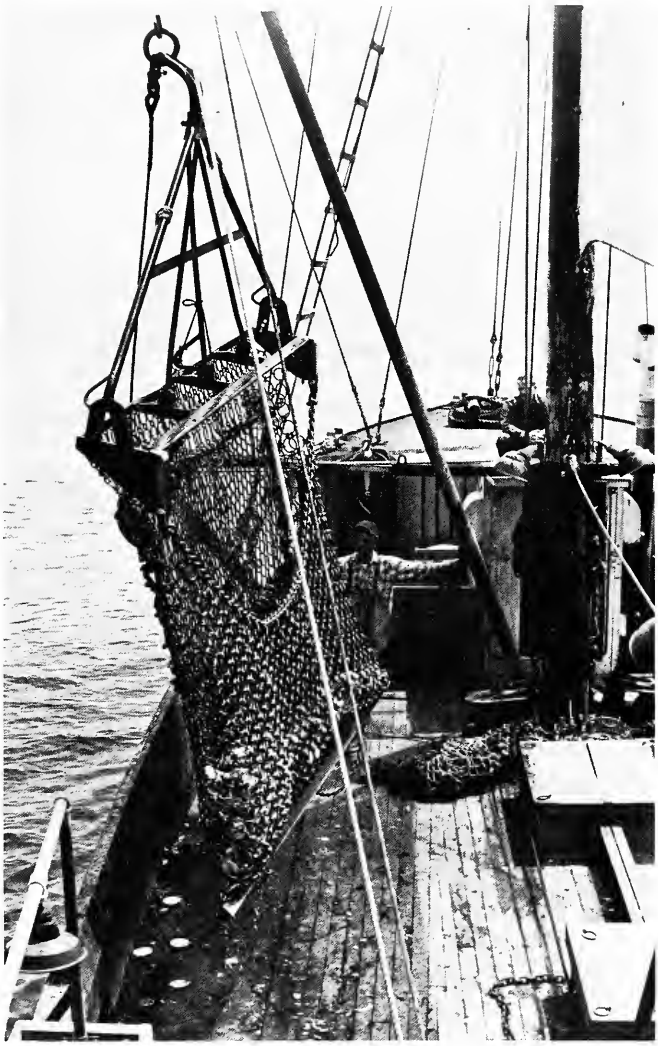
State plants to distant markets. Canned seafoods from Massachusetts are also widely distributed.

The state's largest fish processor is The Gorton Corporation, which operates plants at three Massachusetts ports, Gloucester, New Bedford, and Boston. For generations Gorton's was best known as a processor of salt codfish. This firm was the first to package this product, using a small wooden box with a sliding cover of thin board. The company still produces salt cod, but no longer sells the fish in little wooden boxes. Instead, Gorton's has pioneered the development of convenience seafoods such as the entrees shrimp scampi, scallops in lemon butter, flounder almondine, and sole in lemon butter.

In its Gloucester Seafood Center, Gorton's makes fish sticks and other cooked and breaded products for home consumption and institutional use. Its cannery in Gloucester cans clams, clam chowder, codfish cakes, and fish roe. Gorton's also has a filleting plant in Gloucester, processing ocean perch.

Products of Gorton's New Bedford plant include quick-frozen flounder, breaded flounder, scallops, fried shrimp, fried clams, and onion rings. In Boston, the company produces breaded and fried haddock and scallop portions, swordfish, and flounder dinners. Total employment in Gorton's Massachusetts plants is close to 1,000 persons.

The former General Foods plant in Gloucester might be called the birthplace of the modern quick-frozen foods industry, which encompasses



A scallop dredge swings in-board with its load of deep sea scallops.

not only fish but practically every kind of perishable food. It was in that plant that Clarence Birdseye developed his method of quick-freezing, a method which preserved the nutriment and taste of perishable foods and revolutionized their processing packaging.

Birdseye, an explorer and inventor, had his interest in the preservation of foods by quick-freezing aroused accidentally while sojourning in the Arctic. Noticing that some fish which had been quick-frozen by accident in the extreme Arctic cold seemed to look and taste like freshly-caught fish a long time after the accidental freezing, Birdseye conceived the idea that speed in freezing was the secret of maintaining food quality. His experiments in the Gloucester plant resulted in the development of a mechanical method of freezing foods which outmoded the conventional slower methods previously used.

O'Donnell-Usen Fish Corporation operates a fleet of six trawlers which brings in about one-third of all the fish landed in Boston. Recently this firm opened a large, modern fish processing plant in Gloucester. Among its many products are precooked fish sticks and fish portions, TV dinners, fish dinners, onion rings, and scallops.

Empire Fish Company in Gloucester is a leading producer of precooked fish sticks and fish portions which are sold to wholesalers and large chain stores. The company also processes ocean perch and whiting fillets.

Boston Bonnie Fisheries and the affiliated Bonnie Cold Storage, Inc. are among the larger fish processors in Boston. Their products include frozen fish fillets, precooked fish sticks and portions, scallops, fish cakes, fish steaks, and shrimp.

New Bedford is the world's largest sea scallop port. Some 500 New Bedford fishermen engage in scallop fishing at the height of the season. Fishing is concentrated on Georges Bank, off Cape Cod, the greatest known sea scallop fishing grounds.

Sea scallop shells run as large as 8 inches in diameter. The edible part is the "eye," which is the adductor muscle that enables the scallop to open and shut its shell and propel itself in the water.

Ell-Vee-Dee Co. in New Bedford is a leading shipper of quick-frozen sea scallops. The company is also a large producer of haddock, codfish, and flounder frozen fillets.

Coastal Fisheries in New Bedford does a large business in flounder fillets, some of which it packs fresh in 10 and 20-pound cans. It also produces haddock fillets and precooked scallops.

Aiello Brothers in New Bedford produces frozen and fresh fillets of haddock, flounder, and sole for home and institutional consumption.

Fish by-products are utilized for numerous products. Fish oil and fish meal provide enriching elements in feed for poultry and livestock. Three companies in Massachusetts use fish by-products as ingredients in prepared cat foods. The first is the Usen Canning Company of Woburn, now a subsidiary of the P. Lorillard Company tobacco firm. This firm makes Tabby and Three Little Kittens brands of cat food, using fish by-products as ingredients. It ranks within the top three plants in the country, consuming over 50 million pounds of fish annually and producing more than 500,000 cans of cat food per day. The second, in West Hanover, is the Clark-Babbitt Foods, Inc. It produces both cat and dog for the Calo Pet Food Company at the rate of more than a quarter of a million cans a day. The plant annually consumes some 6 million pounds of fish, in addition to a much larger quantity of meat. Quaker Oats Company, nationally-known Chicago breakfast food concern, recently opened a plant in New Bedford for the production of cat and dog food.

One of the earliest fish by-products was fish glue, which is made from the skins of haddock, cod, or pollock. At Gloucester the LePage's Division of Papercraft Corporation, which makes a wide variety of modern adhesive products, continues to produce fish glue. While the market for it has narrowed, some people still use fish glue for specific uses.

A native food which the colonists learned about from the Indians was the cranberry. Massachusetts today produces about half of the cranberries grown in the United States and sells about 80 per cent of its crop through a marketing cooperative, Ocean Spray Cranberries, Inc.

Cranberry production is concentrated in Barnstable and Plymouth Counties and the area adjacent thereto. Ocean Spray, which has Massachusetts plants at Hanson and Onset, markets a variety of cranberry products. It sells fresh and frozen berries, canned whole cranberries, canned cranberry jelly and bottled cranberry juice. It also makes a cranberry-apple beverage, sold in cans, and a cranberry-orange relish, sold in jars. While Ocean Spray has several plants in other states, about 60 per cent of its processing is performed in the Bay State. Its payments to Massachusetts growers for cranberries purchased total about $6 million a year.

In addition to the canning of seafood and cranberries in Massachusetts, many other kinds of food are canned by Massachusetts processors. These include meat products, baked beans, chop suey, chow mein, spaghetti dishes, ravioli, jams,

jellies, preserves, salad dressing, and pickles.

Wm. Underwood Co. in Watertown is generally recognized as the oldest canning firm in the country. It is famous for its canned deviled ham, which has been produced by Underwood for a hundred years. The company was founded in 1821 by William Underwood, a determined English immigrant who walked all the way from New Orleans to Boston seeking financial support for a canning venture. Among the products first advertised by Underwood were ground mustard and preserved berries and fruits. These early products were packed in glass jars. The company started using metal containers in 1839. Deviled ham was first canned in 1865.

The Underwood company cans sardines and clams at plants in Maine. It also produces the Richardson & Robbins line of chicken products and puddings at a plant in Dover, Delaware. Recently it acquired a controlling interest in Burnham & Morrill Company of Portland, Maine, whose canned baked beans are nationally distributed.

Friend Brothers, Inc. of Malden, now owned by LaTouraine Coffee Company of Boston, specializes in canned baked beans. Its principal product is not to be confused with "pork and beans" sold by leading national canners. "Pork and beans" are cooked in the cans. Friend's beans, with molasses sauce, are baked in pots in brick ovens for eight hours before they are canned. Friend also cans brown bread.

Fish sticks being packed for freezing.

Massachusetts food packers use many millions of cans to preserve everything from soup to nuts.

The Friend business started as a small retail bakery in Melrose, established by Leslie Friend. The baked beans produced at the bakery by Friend and his brothers proved a popular item with the bakery's customers and the Friend brothers saw an opportunity to widen their market if they could successfully can their product. Canning of baked beans was a new field, and the Friend brothers had to design and build their own machinery. They introduced the first canned baked beans in 1918. The new product was an instant success.

John E. Cain Company employs about 450 persons in three food plants in the Bay State. In Cambridge the firm makes mayonnaise and other salad dressing products; in Medford, potato chips and snack foods; and in South Deerfield, pickles and relishes. The company's products are sold throughout New England and in upper New York State.

The segment of the food industry in Massachusetts which has the greatest employment is the one concerned with processing dairy products. Total employment in this branch of the industry is about 7,451 persons in the winter. This total rises about 10 per cent in the summer, when sales of ice cream and other dairy products reach a peak. There are numerous small dairy concerns in the state delivering fluid milk to homes and supplying retail stores. Processing at plants of some of these concerns is confined to pasteurizing, homogenizing, and bottling of milk. Some plants also manufacture such dairy products as soft cheese, soured cream, ice cream, and milk powder.

Most of the $50 million worth of milk produced on Massachusetts farms is handled by these dairy concerns and they are also large buyers of milk produced in Vermont, Maine, and New Hampshire. They also provide a major outlet for the $23 million in eggs produced in other New England states. While eggs are not a dairy product, dairy firms quite generally sell them along with the milk, cream, and other dairy items.

Resembling the control center for a space shot this is actually the heart of a sugar refining center, controlling material-flow and product quality.

H. P. Hood & Sons, Inc. is the largest dairy firm in Massachusetts. The Hood firm got its start in 1846 when Harvey P. Hood, who had come to Boston from Chelsea, Vermont, two years previous with a horse, a wagon, and a pung, established a milk route in Charlestown. Today the company has three milk plants and one ice cream plant in the Bay State. Its main plant in the Charlestown section of Boston probably produces a greater variety of dairy foods than any other dairy plant in the country.

Hood's operations are carried on by four separate divisions. Products of the Milk Division include cream, skimmed milk, chocolate and coffee milk drinks, and eggnog. Hood's Egg Division is one of the largest collectors and distributors of eggs in New England. The Ice Cream Division is one of the state's leading producers of frozen desserts. The rapidly-expanding Food Division produces several kinds of cheeses, soured cream, and cream whip.

Other large dairy firms operating in Massachusetts include Whiting Milk Company, founded in 1837 by David Whiting, and United Farmers of New England, both with headquarters in Charlestown. It has been said that more milk is processed in this small corner of Charlestown by these three New England companies, all next door to each other, than anywhere else in the world. More than three and one-half million pounds of milk are processed daily by Whiting, Hood, and United Farmers combined.

One of the largest and most modern plants in the country producing ice cream is the Sealtest Foods plant of National Dairy Products Corporation in Framingham. This plant can make more than a million servings of ice cream a day. Modern sterilization equip-

ment maintains the highest standards of sanitation in this plant, and an electronic control center regulates the flow of ingredients to the blenders which prepare the ice cream mix. Sealtest has another Bay State plant in Chicopee. Besides making ice cream, this plant also distributes fluid milk.

Howard Johnson Company, which has a chain of more than 700 roadside restaurants in 36 states, makes its famous ice cream for all of the New England states and upper New York State in a plant in Brockton. There, too, it makes bakery products and its line of frozen foods and canned goods which are distributed throughout the United States. In Quincy, where Howard Johnson Company opened its first restaurant, the company has two plants. One plant manufactures its nationally-distributed syrups, relishes, mayonnaise, and candy products. The other facility, a meat plant, not only services all northeastern Howard Johnson's restaurants, but also the Red Coach Grills, its subsidiary chain of steak and lobster restaurants. Quincy is the original headquarters of this now far-flung company which does an annual volume of business in excess of $150 million.

Friendly Ice Cream Corp., started in 1933 in a small Springfield store by two brothers, one a freshman in college and the other just through high school, recently celebrated the opening of its 100th ice cream shop. The brothers, Curtis L. Blake and S. Prestley Blake, rented their first shop for $30 a month and painted tables and chairs to furnish it. Their capital was $547 loaned by their parents, a sum which they repaid as fast as they could out of their earnings. Today the company does a multi-million-dollar business and has a modern manufacturing plant in Wilbraham.

Brigham's Inc. is a manufacturing retailer headquartered in Cambridge. Its 70 retail shops feature ice cream, candy, and bakery products. Brigham's ice cream and candy are manufactured in its Cambridge plant while its bakery products are manufactured in its Allston plant. Its products are sold under the Dorothy Muriel's label throughout eastern New England.

Massachusetts has many meat plants producing ham, bacon, cold cuts, and various processed meats. Most of these products are sold in New England but some are shipped to other areas.

The Chamberlain Division of Armour & Company, with two plants in Boston, produces smoked meats, fresh and smoked sausages, and cured meat products for distribution along the Eastern Seaboard. Armour also has a plant in Springfield for local processing and distribution. Fresh meats are distributed by the Chamberlain Division and branches in New Bedford and Fitchburg.

Swift & Company, while a national concern, was actually started at Barnstable on Cape Cod in 1855. Their New England District Headquarters are located in Somerville. Swift & Company has a total of fifteen units in the Metropolitan Boston area, including one of the most modern facilities in the country that produces hams, sliced bacon, frankfurts, and cold cuts, which are distributed to all of the New England states and a part of New York State.

The Colonial Provision Company in Boston is one of the largest independent packers east of the Mississippi. Its canned ham, smoked shoulder, and turkey breasts are shipped to all parts of the country and exported to Canada and Puerto Rico. The company also produces canned meat for the United States Government.

Among the large meat processing plants are the Columbia Packing Company and the New England Provision Company, both in Boston, and Essem Packing Co., Inc. of Lawrence.

One of the largest segments of the food industry in Massachusetts is that engaged in the production of bakery products. Besides a large number of small bakeries which distribute bread, doughnuts, and pastries locally, there are some big organizations whose markets cover large sections of Massachusetts and extend into neighboring states.

Largest producer of bakery products in the state is Continental Baking Company, which has plants in Natick and Holyoke, with distribution centers at Somerville, Dorchester, Lawrence, and New Bedford. The company's recently completed $9 million bakery in Natick is considered one of the largest bakeries in the world. It is a quarter of a mile from the front door to the back door of this huge one-story, modern structure. Continental's products include bread, cake, doughnuts, English muffins, pies, and pastries.

General Baking Company has a large bakery in Springfield which supplies its outlets in Massachusetts and Rhode Island with bread, cake, rolls, doughnuts and other baked goods.

One of the largest pie bakeries in the world is the modern plant of the Table Talk Pastry Company in Worcester. This plant produces more than a million servings of pie daily and has over 700 employees.

Two Nissen Bakeries, the Nissen Baking Corporation in Lynn and John J. Nissen Baking Company in Worcester, are leading producers of a general line of bakery products.

Another large firm in Lynn is the Cushman Bakery, whose line of some 150 different bakery products is sold house-to-house by self-employed route salesmen operating a fleet of 350 delivery trucks.

Other large bakeries in the state include those of Drake Bakeries Division of The Borden Company, Boston, and My Bread Baking Co., New Bedford.

The Industrial Directory published by the Massachusetts Department of Commerce lists no less than 20 bakeries in the state which have at least 100 employees. Besides providing jobs for hundreds of Bay Staters, the bakeries are important purchasers of ingredients for their products from Massachusetts suppliers. Among the beneficiaries of this business are dairy companies and sugar refineries.

A special section of the bakery industry is composed of firms making biscuits, crackers, cookies, and ice cream cones. There are a dozen such concerns in the state. Largest of these firms is Educator Biscuit Company, Inc. in Lowell, which makes a wide variety of crackers, cookies, and snack items. It regularly employs some 500 workers and at times its payroll climbs to 1,000 workers. The company is a large producer of Girl Scout cookies and it is also a supplier for the United States Government.

Among the larger companies in this section of the baking industry are Ann Dale Products in Fall River and Golden Cookie Company in Watertown. The Austin Dog Food Division of Sunshine Biscuits, Inc. operates a plant in Boston where it produces baked dog food. A small Westminster firm, Dawley & Shepard, Inc., is an important supplier of cracker meal to fish processors for breaded fish sticks and other products.

Candy is one of the Bay State's leading food products. Centered largely in and around the city of Cambridge, this branch of the food industry provides employment for 5,786 persons in Massachusetts.

W. F. Schrafft & Sons Corporation in Boston is one of America's largest candy manufacturers and probably produces more different kinds of candy products than any other firm in the country. Besides a complete line of boxed chocolates, it makes many varieties of hard and filled candies, lollipops, candy bars, patties, gum drops, jelly beans, and specialties. The Schrafft factory in Charlestown is the largest candy plant in New England. It has more than 16 acres of floor space and gets natural lighting from 25,000 panes of glass. Its refrigeration system, which provides ideal temperature conditions for candy-making, has a capacity equivalent to that of 9,000 ordinary household refrigerators.

The firm was founded in 1861 by William F. Schrafft, a German confectioner who had emigrated to this country in 1850. Schrafft worked in confectionery shops in New York and New Bedford before taking a job with a well-known candy concern in Boston just prior to the outbreak of the Civil War. The owner of the candy shop was convinced that the war would ruin his trade, and he sold the business to Schrafft. Schrafft quickly built a reputation as a maker of excellent gum drops and hard candies. Far from wrecking the business, the Civil War provided a market. Schrafft's confections were favorite items for families to send to soldiers at the front.

New England Confectionery Company in Cambridge is another large general line candy manufacturer. Established in 1901 as a merger of three well-known candy houses, the firm has since absorbed several other companies whose trade names were familiar to candy-lovers. The firm sells fancy packaged chocolates carrying the labels of Candy Cupboard, Page & Shaw, Daggett, Apollo, Hand Spun, and Lowney. Other products include Necco Wafers, Sky Bars, Bolsters, and Drums.

The company still makes Canada Mints, the original product of one of the three firms which merged in 1901 to form Necco. This firm was Chase & Company, which got its start in 1847 when young Oliver Chase, an enterprising Bostonian, invented the first American candy machine, a lozenge cutter. With this machine Chase and his brother started the manufacture of Chase Lozenges, the same confection which Necco now sells under the name Canada Mints.

Popcorn balls and hard candies figured in the early history of the other two firms which merged to form Necco: Fobes, Hayward & Company and Wright & Moody. Daniel Fobes made confections from popcorn and maple sugar. William Wright entered the confectionery business with a line of hard candies similar to those produced by English candy-makers.

James O. Welch Company in Cambridge, now owned by National Biscuit Company, is a leading producer of 5-cent and 10-cent bar candies. Its Sugar Daddies, Sugar Babies, Pom-Poms, Junior Mints, fudge, and coconut bars are shipped to the company's warehouses for nation-wide distribution. The company is also a large producer of assorted specialties sold in supermarkets. The firm was started as a one-man operation in 1927 by James O. Welch. Its first product was fudge.

Deran Confectionery Company in Cambridge is a general line candy house producing fancy boxed choco-

lates, bulk candies for chain store outlets, and some bar candies. The company owns Miller & Hollis Corporation in Boston, makers of the Haviland line of high-grade chocolates, and the Hildreth Company of Boston, makers of Velvet brand molasses kisses. The Deran company has its own plant for making the set-up boxes used to package its fancy lines. Baker Extract Company of Springfield, a subsidiary of McCormick & Co., is a nationally known household name in flavoring extracts and food colors.

The Charles N. Miller Company in Boston is a leading manufacturer of penny candy. Its founder, Charles N. Miller, started as a candy wholesaler in 1884, making his own deliveries with a horse and wagon. As a sideline, he began manufacturing candy items of his own, and his first candy kitchen was in a loft in the famous Paul Revere house in Boston.

The company has one principal product, the Mary Jane molasses and peanut butter bar. This confection was developed by Miller in 1914 and he named it for his cousin, Mary Jane. The Mary Jane still sells for a penny. Although it is also made in larger sizes, the penny-size piece still accounts for a major share of the company's sales.

Fanny Farmer Candy Shops, Inc. is one of the largest retailers of fine quality candies in the world, with five manufacturing plants throughout the U.S. In Massachusetts, Fanny Farmer Candies are manufactured in Cambridge which enables the company to service all of their New England outlets on a daily basis.

Many of the old time recipes from the famous Fannie Farmer Cook-Book are used in these products.

Starting with one little white candy shop in 1919 the company now has 375 candy shops and over 2,500 agencies. Ninety per cent of these agencies are drug stores located in towns that are too small to support a Fanny Farmer Candy Shop.

Seviguy's Candy Inc. in Hanover is a leading producer of lollipops, Christmas ribbon candy, and other hard candies.

Other large Massachusetts candy manufacturers include Edgar P. Lewis & Sons, Inc., Malden, and H. W. Powers Company, Boston.

Many tons of fish arrive daily at Massachusetts coastal ports in the holds of fishing trawlers like this one, the *Red Jacket*.

Hundreds of food items are today quick-frozen to maintain flavor and freshness over long periods of time.

Merckens Chocolate Company in Mansfield, which is owned by National Biscuit Company, is a supplier of chocolate coatings to candy manufacturers. It also makes chocolate liquor and cocoa powder, both used in the bakery business, and a candy specialty of its own, chocolate cigarettes.

There is only one company producing chewing gum products in Massachusetts, Gum Products, Incorporated, located in Boston. It has other plants in Oakland, California, and Granby, Quebec. This firm was started 26 years ago in Boston, by Wellington M. Cramer, Jr. Over ten million pounds of chewing gum are produced yearly.

There are more than 100 concerns in the Bay State producing carbonated beverages. Employment in these firms fluctuates from about 2,500 persons in the winter to 3,000 in the summer. In addition to plants which bottle nationally advertised soft drinks under licenses from the parent companies, there are many independent bottlers marketing their own lines of carbonated beverages. While sales of soft drinks in non-returnable bottles and metal cans have grown rapidly, the great bulk of the industry's production is marketed in returnable bottles which must be washed and sterilized at the bottling plants. The biggest outlet for sales of carbonated beverages is supermarkets. Vending machines run second.

The beverage industry in Massachusetts also includes several breweries and several plants producing distilled liquors, as well as firms processing tea, coffee, and cocoa.

Coffee beans from Latin America and tea leaves from India destined for Massachusetts processors make up part of the import volume of the Port of Boston. Coffee is shipped in big bags weighing 132 to 165 pounds, and tea is shipped in large, lightly-constructed wooden boxes called "tea chests." At the processing plant, coffee is roasted, blended, ground, and packaged. Tea is blended and packed either in tea bags or loose in packages. Among the processors of coffee are LaTouraine Coffee Company, Stanley W. Ferguson Inc. (Victor brand), Edmands Coffee Company, and Araban Coffee Company, all located in Boston. Salada Foods Inc., in Woburn is a leading producer of packaged tea.

Located on the waterfront in Boston are the only sugar refineries in New England, the Revere Sugar Refinery and American Sugar Company's Domino Refinery. At their docks ships from all over the world unload raw cane sugar for processing. At these two Boston plants, sugar is refined and packaged for sale to consumers all over New England. In addition, the plants refine sugar for many industrial users, including candy manufacturers, ice cream plants, bottlers of soft drinks, and bakeries.

Revere Sugar Refinery, which is a wholly-owned subsidiary of United Fruit Company, has been processing sugar in the Boston area for nearly a century. Its large plant can produce 3 million pounds of refined sugar daily.

In 1960, American Sugar Company moved into its new, completely-automated plant in Boston. A distinctive feature of this plant is the 100-foot high dome-shaped structure in which raw sugar is stored. The building is large enough to enclose a football field and it can hold 66 million pounds of raw sugar, which is enough, when refined, to satisfy the sugar requirements of every family in Boston for three years.

The Bay State has several firms producing macaroni and spaghetti, the largest being the Prince Macaroni Manufacturing Company in Lowell.

Scattered throughout the state are a dozen firms making potato chips. Among the largest is the State Line Potato Chip Company in Wilbraham, whose chips and cheese popcorn are widely distributed in New England. Several other companies also make popcorn products.

The H. A. Johnson Company in Brighton manufactures fruit fillings, jams and jellies, icing bases, extracts, mixes and bases, toppings and syrups, and ice cream fruit and flavors. The firm is a leading supplier to the bakery, institutional, soda fountain, and ice cream industries. As a wholesaler, the company also distributes a complete line of dried and canned products as well as grocery items.

At Woburn, the Atlantic Gelatin operation of General Foods Corporation makes all the gelatin for General Foods' widely-sold Jello-O desserts. This plant is the largest gelatin factory in the world.

The food service and vending business in Massachusetts, while primarily thought of as a service industry, has come to depend more and more on products of their own manufacture. More than 350 food and vending firms compete for the consumers' dollar in Massachusetts. Among the larger companies are firms like Servomation Corp. whose Northeast Regional Headquarters is located in Medford, which employs some 2,000 people in Massachusetts and operates large, modern commissary and bakery facilities to supply its own in-plant vending needs and to sell to other retail outlets. Principal products consist of perishable consumer items such as bakery goods, doughnuts, sandwiches, and prepared meals.

Within the last few years, both national and local food service

firms such as Canteen Division of Automatic Canteen Co. of America in Waltham; Servend Inc., also in Waltham; Automatic Retailers of America, Braintree; Mystic Automatic Sales Co., Inc., Medford; and Automatic Retail Venders of America, Canton, have built new commissaries in Massachusetts. This centralized mass production of food items by companies primarily engaged in the food service business is a recent trend.

From appetizer, perhaps a cranberry cocktail, to dessert, Massachusetts has appealing foods to offer for every course at the family table. Food is a gift of nature, but it took man's ingenuity to learn how to preserve it and to expand markets from neighborhood areas to all corners of the world. Beginning in 1828, when a Massachusetts concern first hit upon a method of perserving milk for shipment to South America, researchers have struggled with the problem of food storage. Sterilization and vacuum packing, first developed in Massachusetts, made canning successful, and New England seafoods appeared on tables thousands of miles away.

This was only a beginning. New processing and packaging methods helped hundreds of Massachusetts concerns reach out across the nation. With their growth, allied industries in packaging, packaging machinery, labeling, trucking, and scores of fringe operations prospered and grew.

Once harvested by hand and wooden scoops cranberries are picked today by machines that gently rake the berries from the vines and pack them into cases.

The Jewelry and Silverware Industry

Artisans and precious metals build a worldwide reputation for the Bay State

THE JEWELRY INDUSTRY

A man, unknown save by nationality, is responsible for planting the roots of an industry in one Massachusetts community. This community gained international recognition because of its industry. In 1780, one of the countless artisans who migrated to America settled near the boundary of what is now the city of Attleboro. Town annals identify him solely as "The Frenchman," and yet he founded an industry which has made this city one of the three major jewelry producers in the country.

Only thirteen years after "The Frenchman," another visitor known only as "The Englishman" arrived in the area to start what became a thriving button industry. Although "The Frenchman" remains anonymous, it is known that he was one of General Lafayette's soldiers. When the French troops returned to their homeland, "The Frenchman" remained, settling in Attleboro. There he began making silver shoe buckles, decorative buttons, and jewelry novelties. In the first half of the nineteenth century, several jewelry firms were founded and the business gradually grew in importance. Many of these companies or their successors are still in business.

Today Attleboro is generally admitted to be the birthplace of the American jewelry industry. Although some historical references first mention the industry in New York in 1778 and others recall a parade of jewelers in Philadelphia in 1788, there is today a stone marker outside one of the North Attleboro jewelry firms that fixes the plant location as the original site where the American jewelry industry was born "in the Attleboroughs" nearly two centuries ago, in 1780. Although there is great diversification in the industrial complex of the city, with 9,934 persons employed in the more than 139 manufacturing firms, the industrial heart of the community is still producing a wide variety of jewelry and related items. One measure of the value produced by jewelry and all other types of manufactured products may be found in the fact that Attleboro, city of only 27,000 population, has the highest per capita value, $3,478, of products manufactured of any industrial city in all of New England.

In Massachusetts, the jewelry and silverware industry consists basically of jewelry, silverware, and plated ware. High quality jewelry products are made of precious and semi-precious metals such as gold, silver, and platinum, and may include precious and semi-precious stones. Fashion jewelry, the more popularly priced item, is generally made of brass, copper, aluminum, and other base metal combinations, and may be electroplated or, when combined by mechanically bonding thin layers of precious metal such as gold, products may then be described as "gold-filled" or "rolled gold plate," as the case may be. Silverware items consist of flatware, articles for the table that are flat, such as knives, forks, spoons, and platters, and hollow ware, which includes bowls, dishes, pitchers, and similar items used as containers. Both flatware and hollow ware may be made of "sterling" silver for higher quality, or made of base metals and plated with silver, gold or other metals, or combined, such as silver-clad base metal.

The growth in school population throughout the country has been partially responsible for the continued prosperity of Attleboro's jewelry industry, for there has been an increasing demand by students for class rings, club, fraternity and sorority pins, and other school and college awards, insignia, and trophies. The Attleboro area, where most of the Bay State's jewelry manufacture is concentrated, is a leader in the making of "gold-filled" and "rolled gold plate" jewelry.

Although the streets of Attleboro are not paved with gold, the floors in some factories once were. This was before the recent invention of equipment to trap the precious metal which once surrounded workmen's benches—scraps, gold dust filings and shavings, ground into the wooden floorboards. Hence, the adage that a jewelry factory could always get a free new floor by giving carpenters the old one for payment. Even the waste from sinks where workers wash their hands is valuable. Thirty years ago an enterprising group found waste gold in a swamp fed from a North Attleboro river. The river, flowing through the swamp for generations, had deposited enough waste gold to make its recovery commercially profitable.

Besides gold, Attleboro's highly skilled craftsmen work with a variety of other metals including silver,

brass, bronze, copper, and aluminum. Several firms also produce plastic products. One of the most unique is Clearfloat, Inc., which originated and developed the process of embedding materials of almost all types in clear forms of plastic. Small items or miniatures of larger products are embedded singly or in pairs. They are both beautiful and useful as book ends, paperweights, letter openers, key chain tags, and conversation pieces. Diversification, too, has come to this company. They also manufacture large acrylic castings which are used as windows in ships engaged in under-water exploration, and massive castings which are used as windows or neutron shields in nuclear reactors, particularly when used on ships propelled by nuclear power. Other striking examples of diversification in a jewelry community are the plastic radio cabinets molded by Plastimold Corporation and the small parts manufactured particularly of molded nylon by Standard Plastics Company, Inc. for the signal and electrical trade. The latter company also pioneered in the manufacture of plastic jewels for the costume jewelry trade.

In an industry where perfection in the finished product is heavily dependent on hand labor, Attleboro craftsmen take exceptional pride in their workmanship. The skills of the early jewelry workers have been passed on from generation to generation, and the area, which also includes the towns of North Attleboro, Plainville, and Norton, has a

Many jewelry pieces require painstaking hand assembly of several components.

reputation for high quality which is universally recognized.

The list of Massachusetts-made jewelry products is a long one. For women, there are earrings, bracelets, charms, lockets, necklaces, pendants, chains, pins, and brooches. For men, there are tie clasps, collar pins, cuff links, belt buckles, and key chains. For men and women, there are rings, watch bracelets, and a variety of emblematic jewelry. Rosaries and other religious jewelry items are made by several concerns.

In addition to the schools and colleges, manufacturers of emblematic jewelry have steady customers in the large fraternal organizations and service clubs. One Attleboro concern, The Robbins Company, is official jeweler for both the Boy Scouts and the Girl Scouts, and in 1961 and 1965 created the Presidential charms for the several inaugural balls in Washington.

Competition in baseball and football, golf tournaments and tennis matches, both professional and amateur, bring orders for Massachusetts-made athletic medals, trophies, and plaques. Competition in the business world also creates a demand for similar items to be offered as prizes in sales and service contests.

Companies which make jewelry for the retail trade must be constantly alert for changes in fashions and for new fads. People want only the very latest. Yesterday's jewelry may be as out-of-date as yesterday's newspaper.

Not only must the jewelry manufacturer keep pace with new styles in clothing, he must also watch fashions in coiffures. If milady's hairdo covers her ears, she wants long earrings which will show below her hair. If her hairdo exposes her ears, she wants "button" type earrings.

Any hint of a return to popularity of bow ties brings a chill to the manufacturers of men's jewelry. How can you sell a collar pin or a tie clasp to the man who wears a bow tie?

Public events start fads upon which the jewelry industry must be quick to capitalize. The coronation of Britain's Queen Elizabeth, for instance, launched a demand for heavy-crown-type jewelry. More recently, the Unisphere symbol of the New York World's Fair became a popular jewelry embellishment.

The manufacture of metal buttons paralleled the development of the jewelry business. Attleboro had the first factory in the United States making metal buttons and, in an era when metal buttons were much more in vogue than today, the industry thrived. An employee of one Attleboro button factory, John Hatch, invented a machine for manufacturing suspender buttons which were sold under the imposing name of "Hatch's Patent Metallic Pantaloon Buttons."

In Attleboro, too, was the first factory manufacturing gilt buttons. During the Civil War, the company filled large government orders for buttons for the uniforms of Union soldiers. In Attleboro Falls, V. H. Blackinton & Co., founded in 1852, has been manufacturing official insignia for all branches of the armed forces since the Civil War!

Expansion of the jewelry industry in the Attleboros of the early days came largely through the creation of numerous small companies rather than through the rise of any single giant. Today, although the Attleboro area has several large companies, there are still many small shops.

Largest of the Attleboro jewelry companies is L. G. Balfour Company, manufacturers of emblematic jewelry and the largest fabricator of gold items in the world. The firm employs 2,000 persons.

The founding of the Balfour Company in 1913 was rather typical of the origin of many new companies in the area. Lloyd G. Balfour was a salesman who thought there was a better way to do business. For five years he trudged from campus to campus selling jewelry to college fraternities. He was not happy with the product he was selling nor with the service he was able to give his customers. Emblem designs on the jewelry often were poorly reproduced and orders frequently were not delivered on time.

Balfour decided to go into business for himself. He enlisted the services of a small group of skilled Attleboro jewelry workers including a production man, a tool-maker, a die cutter, and a stone-setter, and launched the venture. From the start he insisted on superior workmanship and he was meticulous about meeting delivery dates.

Today the Balfour Company is not only famous as a producer of emblematic jewelry and class rings for schools, colleges, business firms, and fraternal organizations, but it has developed a growing business in related lines. Besides jewelry, it offers products in leather, ceramics, engraved diplomas, and graduation invitations.

Another well-known Attleboro company is Swank Inc., the largest manufacturer of men's jewelry in the world. Swank's line of masculine jewelry, sold in some 24,000 retail stores, consists of about 3,000 items. These include cuff links, tie tacks, tie clips, key chains, collar pins, and tuxedo sets. The company, which spends more than a million dollars a year to advertise its products, employs 1,200 workers.

Historians claim that jewelry charms date back to the tombs of Egypt. Although originally used as a means of identification, they are now purchased as mementos of senti-

mental or personal events in the wearer's life. One of the oldest names in the charm industry is the J. M. Fisher Company of Attleboro, which has been manufacturing charms of all types for 85 years. This firm produces hundreds of styles of charms, many of the movable type, in 14K gold, sterling silver, and gold plate.

With a new plant in Attleboro's Northwest Industrial Park and some of the most modern equipment in the industry, Wells Inc. has shown remarkable growth in recent years. It is one of the world's largest manufacturers of so-called "movable" charms. These are charms with movable parts—if the charm represents an automobile, the wheels of the car turn; if it represents a clock, the hands turn.

Among the larger employers in the industry in Attleboro are Shields, Inc., specializing in men's jewelry; Leavens Manufacturing Company, a major producer of emblematic jewelry; and Simmons Division of Josten's Inc., manufacturing gold-filled and sterling jewelry. One Greater Attleboro firm, Whiting & Davis Company, Inc. of Plainville, boasts the invention of the world's first mesh-making machinery. This produces a most unusual product, chain mesh, which not only goes into glittering and fashionable ladies' handbags but has been made into chain mail mesh costumes for several Hollywood motion picture epics, including "Joan of Arc" and "The Crusades."

Stability in the jewelry industry may be measured to a great extent by the long years of continuity in business. Several companies in the Attleboros have succeeded in business for several decades. Two examples of such longevity include the Walter E. Hayward Company, manufacturers of medals, religious goods, and specialty jewelry for 114 years, and the H. F. Barrows Company of North Attleboro, founded in 1851, which specializes in lockets, pendants, and religious goods.

Supplying materials and parts to the jewelry fabricators are a number of firms in Attleboro and North Attleboro. Several concerns including the city's largest and most diversified company, Metals & Controls Inc., a subsidiary of Texas Instruments Incorporated, and the 65-year-old Leach & Garner Company, furnish jewelry manufacturers with karat gold, sterling silver, and gold-filled materials. This latter company also furnishes solid and laminated precious and non-precious metals in the form of sheets, wire, and tubing to other allied industries. Under the same owner-management as Leach & Garner is General Findings, Inc., the largest of a number of firms supplying the jewelry industry with such findings as ear wires, ear clips, spring rings, swivels, beads, and balls.

Relatively few companies of any size in the jewelry industry are located outside the Attleboros. One of the largest, catering exclusively to college stores and retail jewelry shops, is the College Seal and Crest Company of Cambridge. Founded in 1875, this firm made the first college seals ever used for commercial purposes.

Precious and semi-precious stones are carefully positioned and fitted by hand.

Skilled hands cut the delicate lines in a die used in the manufacture of rings.

THE SILVERWARE INDUSTRY

Paul Revere, Revolutionary patriot, was America's most famous silversmith. Boston-born son of a silversmith, he was trained in his father's trade. While he is more widely known for his famous ride to Lexington and Concord, many of his works as an artisan are now regarded as masterpieces of his craft, particularly the very popular Paul Revere bowl which is reproduced today by several Massachusetts companies.

Unlike the jewelry industry's concentration in one area, the manufacture of silverware in Massachusetts is scattered throughout the state. There are major producers of silverware in Taunton, Newburyport, and Greenfield.

The largest manufacturer of silverware is Reed & Barton Corporation of Taunton, which had its beginnings in the 1820's. At that time Americans were turning away from the use of pewter for tableware. They were buying dishes of imported china, porcelain, and pottery to replace the pewter plates and mugs that had been used for generations. And they were buying teapots and bowls made of an attractive new metal developed in England called "Britannia."

Britannia, an alloy of tin, antimony, and copper, had much more luster and was easier to clean than pewter, which is an alloy of tin and lead. Moreover, it was more durable, lighter, and more resistant to heat.

This trend from American-made pewter to imported Britannia disturbed Isaac Babbitt, a Taunton jeweler. He determined to find the secret of making Britannia and, although he had no technical training as a metallurgist, he kept experimenting with different combinations of metals until he was able to duplicate the British product.

Babbitt interested another Taunton jeweler, William Crossman, in the project and soon the Taunton Britannia Manufacturing Company was established. Among its early products were Britannia inkstands, shaving boxes, looking-glass frames, and teapots.

While Babbitt and Crossman started the enterprise, it was two employees of the firm, Henry Reed and Charles Barton, who really developed the business. In 1835 they became sole owners and the name of the concern was changed to Reed & Barton.

Today the Reed & Barton Corporation plant in Taunton employs nearly 900 workers. It makes sterling silver and silver plated flatware and hollow ware, as well as a line of stainless steel flatware. Their North Attleboro subsidiary, the Webster Company, makes sterling baby items, dressware, and flatware.

In Taunton, too, are several other silverware manufacturers: Poole Silver Company, Inc., Sheridan Silver Co., Inc., and the F. B. Rogers Silver Company, which employs approximately 400. This company has been in operation

Spinning a sterling bowl to achieve desired shape.

Hydraulic presses stamp out basic forms for silver hollow ware.

since 1883, and its crown trademark has long been recognized as a symbol of quality and craftsmanship.

In Newburyport the long-established Towle Manufacturing Company makes flatware and hollow ware in sterling silver. Commonly called "solid silver," sterling is actually an alloy in which a small amount of copper is added to pure silver to give it added strength. The Towle Company is the direct successor to the Moulton family, who started their careers in silversmithing in 1690 in Newburyport. The six consecutive generations of Moulton silversmiths followed by the Towle silversmiths represent 275 years of silver craftsmanship without interruption on the banks of the Merrimack River in Newburyport. Few, if any, other American communities can claim such a long succession in any one craft or industry. Towle silversmiths today, as do all manufacturers who produce items described as being sterling silver, use exactly the same formula that was prescribed centuries ago for the medieval coin called "Sterling": 92½ per cent pure silver, 7½ per cent copper.

Greenfield is the home of another well-known name in fine silverware, Lunt Silversmiths. Until quite recently, this firm manufactured sterling items exclusively, but it has now added a line of plated ware.

Wedding bells have a distinctly merry ring to the state's silversmiths. One manufacturer estimated that 75 per cent of his annual production of sterling silver was purchased as gifts for brides. The fact that an increase in the number of marriages is forecast for the late 1960's is regarded as a good omen for business in the industry.

Both jewelry and silverware manufacture require a considerable amount of hand labor. Although some processes, such as the making of chains, have been taken over by automatic machines, there are limitations on the amount of automation and mechanization that can be introduced. The making of a piece of sterling flatware may involve as many as 60 operations by hand.

Total employment in the jewelry and silverware industries in Massachusetts in 1963 was nearly 7,400, with an annual payroll of about $38.5 million. The value added by manufacture was $62.5 million.

Involved as the early Bay Staters were in the prosaic economic development of basic needs, grace and beauty were not forgotten. Pioneering silversmiths produced silverware of such form and charm that its possession is still sought today. Fortunately the art has continued through generations to produce Massachusetts-made silverware known throughout the world. The craftsmanship of the jewelry maker working with common and precious metals, wood, plastics, common and rare stones has enhanced Massachusetts' reputation for quality-made products.

Artist's designs are reproduced on silver through the hands of expert engravers.

The lustrous, smooth sheen of silver is achieved through skilled grinding and buffing.

The Research and Development Industry

"Invention breeds invention" in Bay State's "think" laboratories

A can of frozen orange juice in the refrigerator, and a zirconium-clad fuel rod in a nuclear reactor—what do they have in common? Both were made possible by research-and-development, Massachusetts-style. The first successful frozen citrus concentrate came out of National Research Corporation, a subsidiary of Norton Company, Cambridge, a company which also achieved the first interplanetary space vacuum system. NRC is now heavily engaged in research on materials behavior, refractory metals, electron beam technology, superconductors, and high vacuum equipment.

The use of the material zirconium for nuclear reactor components was conceived and first advanced at the Nuclear Metals Division of Textron Inc. of West Concord.

Not all research and development results in dramatic advances, but research and development is the seedbed of the future. "Invention breeds invention," Ralph Waldo Emerson pointed out. Today, one out of every 10 workers in the Greater Boston area is an engineer or scientist. These 30,000 degree-holding professionals make Greater Boston a place where "invention breeds invention."

In fact, the research and development industry is perhaps the largest single industry in the Boston-Cambridge area. The great universities of the area are the chief attraction for research and development activity, both government and private. The universities and technical institutes provide the R & D industry with the basic research which nourishes it and the intellectual climate which helps it grow. It is not by accident that great government centers of R & D work are located in eastern Massachusetts. These centers include Air Force Cambridge Research Laboratories, Air Force Electronic Systems Division, Lincoln Laboratory, and the Natick Research Laboratories of the Army. Many of the private, industrial R & D facilities are direct offsprings of the universities, and others were established here in order to be near these centers of excellence.

R & D is a valuable asset to Massachusetts. A ride on Route 128 from Beverly to Braintree shows why. R & D can flourish in handsome, landscaped parks without noise, smoke, or neighborhood blight. Research parks are springing up all over the nation, and many are trying to attract part of the R & D industry away from Massachusetts. The principal weapons in the battle are the scientific and technical excellence of the area's people and schools. Unlike other industries, R & D requires neither proximity to raw materials nor to centers of distribution. It requires proximity only to institutions of higher learning.

R & D includes both basic research in the sciences and development, or applied research, in which efforts are made to produce new devices, new techniques, or new materials.

In space exploration, in defense of the nation, and in industry, these activities will be the key to the future. Says Dr. Albert Kelley of NASA's new Electronics Research Center in Cambridge: "New electronic systems not yet invented will be needed for future space and planet explorations." The same is true in defense, in industrial processes, in transportation, in food technology, and in virtually every area of human activity.

One of the most important areas for R & D today and in the future is materials. In addition to materials research at Bay State universities, several industrial R & D laboratories are world leaders in materials research.

Nuclear Metals of West Concord, a division of Textron Inc., develops improved metals, alloys, ceramics, and new methods for their production into useful shapes such as aerospace structural components. Nuclear Metals is one of the top R & D companies working to develop exotic materials and fabrication methods which someday will find routine application in aerospace structures and make nuclear power more economical and practical.

Because of the outstanding work in materials studies going on in Massachusetts, Kennecott Copper Corporation chose to build its Ledgemont Laboratory in Lexington. Ledgemont Laboratory, a research center for the study of materials and their applications in industry of the future, is one unmistakable example of the national recognition given to R & D in Massachusetts. Kennecott Copper is only one of the many non-New England companies which, though they have no production

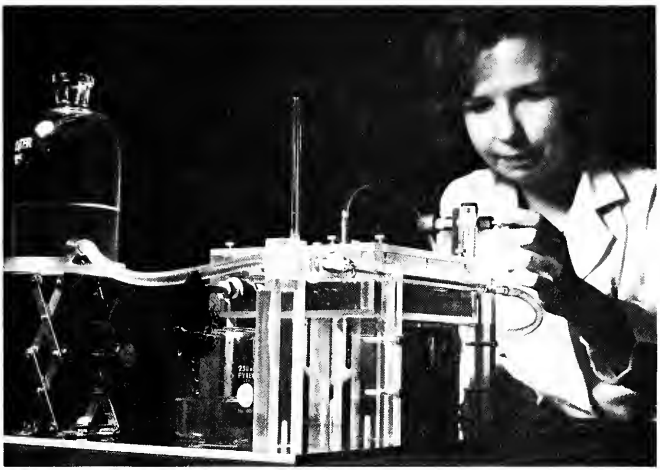
facilities here and no historical ties with Massachusetts, have nevertheless chosen to set up R & D laboratories here.

Sperry Rand Research Center in Sudbury is another example. Here, in the countryside of Thoreau and Emerson and Hawthorne, a group of more than 100 scientists do basic and applied research in electronics, physics, chemistry, and other disciplines which will yield new devices and techniques for the world-wide interests of the Sperry Rand Corporation.

P. R. Mallory Company, an electronics manufacturer whose roots are in the Midwest, set up its corporate research center in Burlington.

General Motors, the largest corporation in the world, has an important research center in Wakefield, on Route 128. AC Spark Plug, the electronics division of General Motors, works there on inertial guidance, a technique developed at Massachusetts Institute of Technology. This technique is used on Polaris and other missiles, and will be used to guide the Apollo space ship to the moon.

The Radio Corporation of America, with facilities in Burlington and Needham, and the Avco Corporation, which does extensive R & D work in Everett, Wilmington, and Lowell, are other examples of companies which want to be as close as possible to one of the world's great R & D centers. Much of the electronics associated with the manned lunar landing, subsequent ascent from the moon and the rendez-vous with the Apollo



Measurement of moisture vapor transfer through fabrics is a criterion of comfort for apparel.

Inspecting the honeycombed heat shield for the Apollo Command module before applying the ablative material that will protect the astronauts from temperatures ranging up to 5,000° F.

mother ship is being designed, developed, and manufactured at RCA's Burlington plant. At RCA's Needham facility, critical memory cores are manufactured for the computer industry.

Constant research in the field of energy conversion contributes to the continuous technological advances in the United States space program. Tyco Laboratories, Inc. of Waltham has carried on extensive work in the development of fuel cells and high energy batteries essential for extended flights of the Gemini and Apollo series.

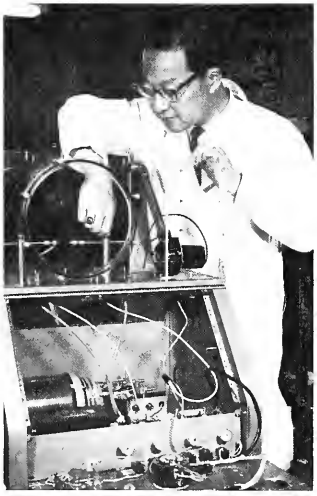
Arthur D. Little, Inc., whose headquarters are in Cambridge, is one of the world's oldest, largest, and most diversified contract research and management consulting companies. Its services are offered to companies, trade and industrial associations, cities and regional governments, the government of the United States and of other countries, investment firms, and individuals. Its services range from basic and applied research in the physical and biological sciences to the formulation and implementation of economic development programs.

The company's services include product and process development; engineering design; market and marketing research; analyses and design of inventory control, physical distribution, and information handling systems; and diversification, acquisition, merger, and other planning studies. It is the range of services within one consulting company that enables Arthur D. Little, Inc. to deal uniquely with complex problem-solving situations. Some of the pioneering work of the company includes flavor and odor research, cryogenics, and the use of operations research in industrial and business problems.

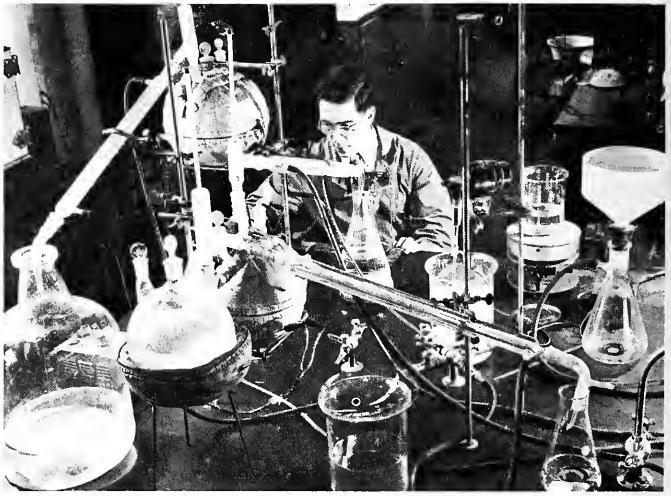
Another company with taproots in the Bay State is Cabot Corporation, world leader in the production of carbon black. This company has been producing this important industrial product since 1882, when the flicker of a gas flame against a metal plate created the soot known commercially as carbon black. Today Cabot makes carbon black from both gas and oil and is the only manufacturer to produce all three basic types of black, channel, furnace, and thermal, providing more than fifty distinct grades in all.

Carbon black is used as a reinforcing agent in both natural and synthetic rubbers. Four pounds of carbon black in an average automobile tire can add as many as 20,000 miles to the life of the tire. Carbon black is also used as a coloring pigment in paints, inks, plastics, and paper.

The Cabot Corporation headquarters are in Boston, and its principal laboratories for research in carbon black are in Cambridge. The company has a research center and pilot plant in Billerica for development of new products. On this 65-acre site near Route 128, R & D work is expanding the list of Cabot products derived from what the company describes as "flame technology."



Development of tester to measure flammability of fabrics in environments containing various oxygen concentrations.



The world of plastics still holds many new developments for the research chemist.

One of the Cabot products is titanium dioxide, a whitening and opacifying pigment used in paint, paper, plastics, rubber, ceramics, and floor coverings. Another is an extremely fine pyrogenic silica (silicon dioxide) used as a thickening and free-flow agent in over thirty industries. This silica is important in the preparation of paints, hair lotions, plastic resins, and industrial lubricants. It is used in such ordinary products as sodium bicarbonate and common table salt.

The computer is without doubt the most important tool in today's R & D industry. The computer enables research staffs to build mathematical models of complicated operations such as the management of a nationwide corporation with dozens of divisions, or the planning of military strategy on a global scale. The computer allows top managers, industrial or military, to see how the complete system works, and to pick out problem areas. This type of activity is called Operations Research. It is one of the many specialties of Technical Operations Inc. of Burlington.

R & D teams from this company have analyzed techniques of processing weather information as a part of the government's effort to reduce air collisions. These teams also have explored alternative methods of handling huge shipping containers in the freight trade between the West Coast and Hawaii. They are continually working with senior military officers to help develop new tactics and field organizations for the Army of the future. And they use giant computers to assist the Army and Air Force in strategic planning and evaluation of future operational concepts for supply of military units in battle.

Another application for computers originated at the United States Air Force Spacetrack installation in Bedford. There the Spacetrack computer system designed and implemented by the Wolf Research and Development Corporation of Concord maintains a continuous around-the-clock surveillance of all space objects orbiting the earth.

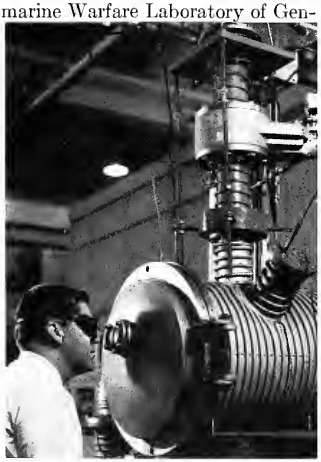
The scientist thinks of sound as a mechanical disturbance in the air, or sometimes in liquids and solids. But most of us think of sound in terms of speech and singing, the radio and TV, the roar of missiles, and the high-pitched hiss of jets. A company in Cambridge, Bolt, Beranek and Newman, is recognized throughout the world as a leader in the measurement and analysis of the whole range of sound, desired and undesired. BB&N has assisted in the acoustical design of some of the great music halls of the world. Recent projects included the National Theater of Singapore and the War Memorial Auditorium at Boston's new Prudential Center. BB&N scientists and engineers are also analyzing noise patterns measured during takeoff of jets from Kennedy International Airport in New York. Others are investigating noise levels on various kinds of highways, in an effort to determine the effect of noise on automobile drivers. The company also specializes in computer applications, and is developing a computer system for hospitals to assist in handling medical records of patients and the history of their

In the eerie glow of the gas discharge tube a scientist studies the beam pattern of continuous wave laser output.

treatment. For a number of years this firm has been engaged in research, development, and consulting on many aspects of underwater acoustics, such as sound radiation, transmission, attenuation, and detection. Studies of problems in the areas of sonar systems and anti-submarine warfare are an integral part of the program.

Another Cambridge organization, United Research Inc., carries out studies in transportation and logistics, business and economic forecasting, marketing research, and military project management. URI's clients include government agencies and many leading United States industrial organizations.

Anti-submarine warfare is an area of expanding interest for the Massachusetts R & D industry. Two non-New England companies have set up special laboratories in this state to develop capabilities in underwater acoustics and sound ranging. They are the Anti-Submarine Warfare Laboratory of General Instrument Corporation, located in Westwood, and the Electro-Acoustic Systems Laboratory of Hazeltine Corporation, located in Braintree and Avon. A young Marion firm, Braincon Corporation, designs and manufactures instruments and vehicles for underwater research.



A researcher peers through the viewer of advanced electron beam equipment used in the production and development of superconducting niobium films. This film varying in thickness from one millionth of an inch to one thousandth of an inch may provide the solution to many proposed electronic devices.

In Waltham, the Information Sciences Laboratory of Litton Systems is conducting research in pattern recognition techniques for detection of submarines, in which the equipment, not the operator, will make the determination.

The astounding variety of R & D activities in Massachusetts is an impressive testimonial to the state's climate of creativity. Dow Chemical Company chose Wayland for its eastern research laboratory in which scientists pursue basic research in chemistry. In Wellesley, the Cerand Corporation investigates new materials and processes for the construction industry. The Corn Products Food Technology Institute is a new and unique organization which was established in the summer of 1964. From its headquarters in Waltham, it conducts and coordinates investigations by a worldwide network of research facilities into every aspect of food production from the planting and growing of the raw product to its preservation, processing, and packaging. The Institute, which is supported by Corn Products Company, works with all forms of vegetables as well as with livestock, poultry, and fish. Allied Research Associates, Inc. of Concord performs research projects for government and industry in space meteorology and physics, and in advanced structures and materials. Diffraction Limited Inc. of Bedford explores the world of optics and makes, for example, special lenses for satellite cameras. In Burlington, Ion Physics Corporation is developing nuclear bomb simulators as well as creating semiconductors by ion implantation. Fabric Research Laboratories Inc. in Dedham tracks down new product possibilities in textiles, plastics, and paper. The Helio Aircraft Corporation in Bedford is studying the problems involved in the takeoff of small light airplanes from a standing position. Dynamics Research Corporation of Stoneham conducts extensive analysis and evaluation of both underwater and space navigation systems. Space Sciences of Waltham produces the high temperature measuring device used in the Gemini re-entry heat shield to record temperatures in excess of 5,000 degrees for short periods of time. Ilikon Corporation of Natick has developed a process for making hollow articles in a broad range of sizes and thicknesses by forcing a molten bubble into a die by means of a gas.

Mitre Corporation, a non-profit organization originally sponsored by Massachusetts Institute of Technology, at its facilities in Bedford employs 1,800 persons designing and engineering such computer-based systems as the NORAD Combat Operation Center, the Sea Launch Ballistic Missile Defense System, and the SAGE Air Defense System. Mitre works exclusively with government agencies: the Air Force, the Department of Defense, and the Federal Aviation Agency.

And there are the dozens of "think and write" companies where senior scientists and engineers pursue mathematical and systems analysis of technical problems. All these are part of the "innovation industry" which thrives in the New England environment of creativity.

R & D is, of course, not confined to those companies that specialize in this type of enterprise as their

principal business. Every manufacturing company, large or small, must engage to some degree in research and development in order to stay in business and to keep its products and services competitive. Many companies maintain very extensive R & D laboratories within their own plant facilities. These labs or departments expend substantial sums of money seeking new products or methods and techniques of improving their current products to satisfy the ever-changing needs of customers.

Young people are sometimes tempted to decide that there is not much more to be invented, that everything has been done. This is far from the truth. It is almost universally predicted that half of the products we will be using in daily living 25 years from now have not been thought of yet. They will emerge out of R & D. And many will bear the label "created in Massachusetts."

Technicians fit the Apollo Command module forward section to the crew compartment section.

Other Industries that Support our Economy

Variety adds spice to the manufacturing mix

THE RECREATION INDUSTRY

Toys and dolls have been found by archeologists in the tombs of ancient Egyptians. Primitive people like Eskimos have for generations carved ivory from the tusks of walrus into playthings for their children. Discus throwing was a sport enjoyed by the ancient Greeks, and later the Romans took up chariot racing and built arenas where gladiators, slaves and captured prisoners of war fought each other to the death with swords or a skull cracking band of heavy metal fastened around their wrists, and known as a cestus. It has been said that the battle of Waterloo was won on the playing fields of Eton where the flower of England's young men were trained in sports and teamwork and encouraged to compete.

To serve the recreation industry, Massachusetts produces a wide range of products including toys, dolls, games, sporting goods and athletic equipment, musical equipment, and cameras. The manufacture of bicycles and boats, two major segments of the "leisure time" industry, are described in the chapter covering the Transportation Equipment Industry.

As closely as can be determined, Massachusetts has about fifty manufacturing establishments employing nearly 4,000 people, engaged in producing toys, dolls and doll carriages, velocipedes, other wheel goods, and games to the value of approximately $73 million annually. Its estimated annual payroll is around $14 million.

The majority of the companies producing toys in Massachusetts are relatively small firms, most employing less than 100 workers. However, in the manufacture of plastic toys, for which the Fitchburg-Leominster area is the main center, the Star Manufacturing Co. in Leominster, with a work force that ranges between 200 and 300 people, ranks as the largest. Largest manufacturer of wood toys in Massachusetts is the N. D. Cass Co. in Athol which employs more than 200 workers.

The manufacture of wheel goods and children's vehicles including velocipedes, metal carts, doll carriages, and strollers is centered almost entirely in the Fitchburg-Gardner area. The five leading companies are Collier-Keyworth Co., Comet Mfg. Co. and Thayer, Inc., all in Gardner, and the Hedstrom Union Co. and the S. & E. Mfg. Co., both in Fitchburg. The Iver Johnson Arms & Cycle Works in Fitchburg, long known as a manufacturer of bicycles, now confines its manufacturing mainly to revolvers and shotguns for sportsmen.

The Milton Bradley Company of Springfield is not only the largest but one of the oldest companies in the toy industry in Massachusetts. It is also among the largest and most diversified companies in the toy industry in the country. It was founded in 1860 by a young man, Milton Bradley, who journeyed from Hartford to Springfield to start his business career. Employed first as a draftsman for a railroad car manufacturing company, Bradley, fascinated by the art of lithography, decided to establish his own business with the purchase of a lithograph press.

Typical of many Yankee pioneers, Bradley was soon diverted away from the ordinary business of lithographic printing and attracted to the field of education, in this instance, the kindergarten. Fired by the enthusiasm of Elizabeth Peabody of Salem, an exponent of the theories of Frederic Froebel, the German father of the kindergarten movement, Era lley manufactured the first kindergarten "gifts" which Froebel had proposed. From this beginning over a century ago, has grown one of the most fascinating enterprises in the region.

While primarily known as a manufacturer of board games, puzzles and card-type games, the Milton Bradley Company also markets a substantial line of teaching aids, school art supplies and a specialized line of school furniture. Although the company emphasizes products for teen-age children, they are also in the business of providing games for adults which include board and card games, jigsaw puzzles as well as creative action and skill action games. Among the company's most popular and familiar games are included the children's board game "Uncle Wiggley," first produced in 1917, the quiz game, "Go to the Head of the Class" and two memory games "Password" and "Concentration." The firm employs 1,000 at its Springfield and East Longmeadow plants.

Parker Brothers, Inc. in Salem, employing 350 people, dates its

beginning back to 1882. The company, one of the best known publishers of indoor home games for both children and adults in the United States, produces the popular game of "Monopoly" among many others.

The J. L. Hammett Company in Cambridge is a name synonymous with a complete line of school supplies and equipment, as well as the manufacture of bulletin boards, chalkboards and wooden instructional toys. They also employ 250 New England artisans. Another firm, The Electric Game Co. of Holyoke, specializes in the manufacture of games which are electrically operated.

Another veteran of the toy industry in Massachusetts is Noble & Cooley Co., located in the small Berkshire town of Granville. This company has specialized in the manufacture of toy drums and tambourines for more than 75 years. A small company in Wakefield, Paul K. Guillow, Inc., employing between 35 and 60 people, began operations in the mid twenties and now manufactures ready-to-fly model airplanes and do-it-yourself construction kits exclusively. It has customers nearly all over the world.

Vogue Dolls, Inc. of Malden is the largest manufacturer of dolls and doll clothing in New England. It employs between 50 and 150 workers in its main headquarters in Malden and its stitching plant in Laconia, New Hampshire, depending upon the seasonal demand for its products. The company was founded in the early 1920's when Mrs. Jennie H. Graves began mak-

As long as there are little girls there will be a market for dolls. Wigs with the latest hair styling are attached by hand.

Piece by piece, under the skilled hands of many people, a game grows to a finished product.

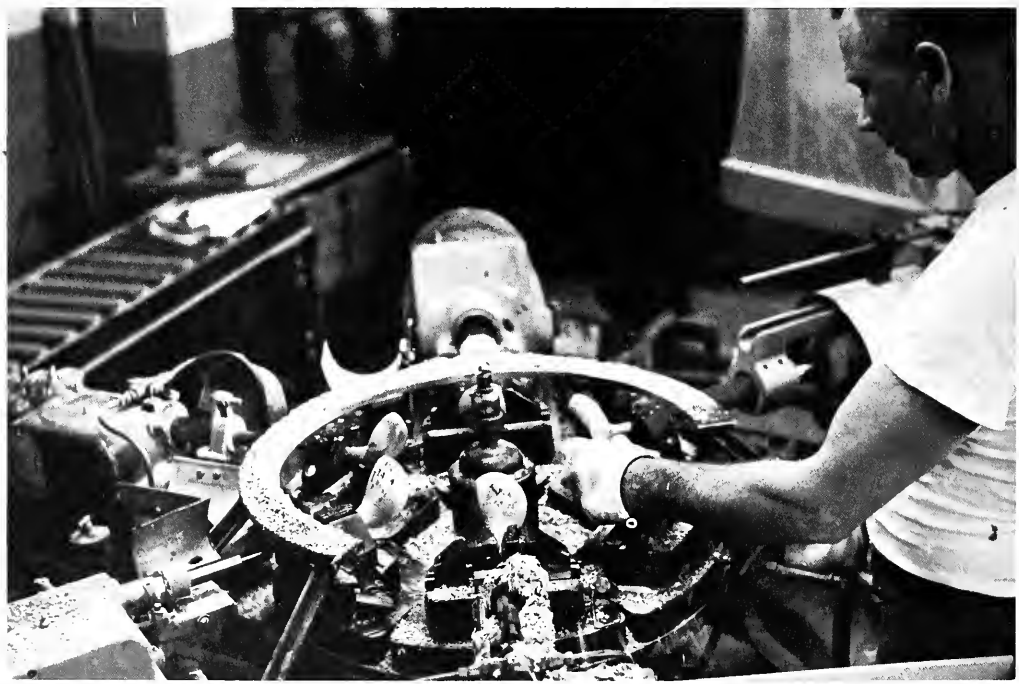
ing dolls' clothing as a hobby and gave them to local churches to sell at their fairs and bazaars. From this small beginning, the company grew to a position in the mid fifties where it was the innovator and the largest manufacturer of miniature dolls with wardrobes and clothes for all occasions. Since that time it has diversified and presently makes a wide variety of dolls from 8″ to 25″ in size. Vogue Dolls has created many revolutionary innovations in the doll industry and its output is sold in all fifty states. Totsy Manufacturing Co., Inc. of Holyoke and Peggy Ann Doll Clothes, Inc. of Springfield design and manufacture both doll clothes and accessories.

Materials used by the toy industry and the related sporting goods and athletic equipment industry include rubber, plastics, textile fabrics, wood, ceramics, metal castings and metal stampings, wire, paints, inks, dyes, and adhesives. Paper is also an important factor in the production of games. General Fibre Products Co. in Fitchburg, manufacturers of doll trunks, vinyl and metal toy luggage, laundry and skate cases, for example, uses cardboard for reinforcing and paper as a lining material for these products.

One of the oldest companies in Massachusetts, the Rugg Manufacturing Company in Greenfield, which was established in 1842, and whose main product is lawn rakes and snow tools, brought out a line of children's snow shovels several years ago and finds them in big annual demand.

SPORTING AND ATHLETIC EQUIPMENT

In the field of sporting goods and athletic equipment Massachusetts is a star performer. The 33 companies in this group furnish employment to approximately 5,200 people, and make equipment and gear for nearly every major sport. The list of products includes golf balls and golf clubs, fishing rods and tackle of all kinds, ice and roller skates, shoe skates, ski bindings, shotguns and rifles, baseballs and softballs, tennis rackets and table tennis equipment, bowling balls and automatic pinsetting machines, hockey pucks, inflatable rubber and vinyl rafts, and beach balls. Add to this, athletic uniforms and protective items such as shoulder pads and shin guards.



The first American-made golf club was produced in Massachusetts in 1894 introducing a sport that has grown steadily in popularity.

An outstanding company in the world of sports is A. G. Spalding & Bros., Inc. in Chicopee, established in 1876, the same year that the National Baseball League was formed. This company has the distinction of having manufactured all the baseballs ever used in the major leagues since their inception. Back in 1894 Spalding created the first American-made golf club and, in 1898, the first domestic golf ball. The first American-made tennis balls were produced by. Spalding, following the introduction of tennis to the United States in 1880. This company also manufactured the first American football. The Spalding factory in Chicopee contains more than 500,000 square feet of manufacturing space and employs more than 1,000 people. The Acushnet Process Company in New Bedford, referred to in the chapter on the rubber and plastics industry, is another leader in the production and distribution of golf balls and equipment. They manufacture golf balls and putters and distribute these products, plus other golf equipment, through the golf professional at the country club. This company employs over 1,000.

Converse Rubber Co. in Malden, employing more than 1,000 people, is the nation's leading producer of basketball shoes. Among the many professional basketball stars who wear Converse shoes are Boston's champion Celtics, including Mel Counts, who takes a giant-size 18. Converse basketball shoes are worn by many leading college and high school basketball teams, too. Converse also makes special shoes for tennis, boating and wrestling, as well as parkas for school football players and warm-up jackets for baseball players. A subsidiary, Tyer Rubber Corp., in Andover, makes the official pucks used by both the National Hockey League and the American Hockey League. It is the largest producer of hockey pucks in the United States.

Several Massachusetts firms make uniforms and protective equipment worn by professional athletic teams. Tim McAuliffe, Inc. in Boston, supplies uniforms worn by several major league baseball clubs. It has outfitted the Boston Red Sox, the Kansas City Athletics, the Los Angeles Dodgers, the Los Angeles Angels, and the San Francisco Giants. The company also makes uniforms for more than 100 colleges, including such Ivy League institutions as Harvard, Dartmouth, and Brown. A unique organization, Ivory System, Inc. of Peabody, provides a nationwide service in the re-conditioning of all kinds of athletic equipment for schools and colleges, as well as professional sports teams.

Stall & Dean Manufacturing Co. of Brockton, founded in 1898, is another leading Massachusetts maker of uniforms for major league baseball and professional hockey teams. Its products also include hockey gloves and other protective clothing worn by hockey players. The J. E. Pender firm in Boston supplies professional hockey teams, including the Boston Bruins, with such protective items as shoulder pads, elbow pads, and shin guards. It also equips high school and college hockey teams with helmets and protective equipment. Canvas golf bags and sports equipment carry-alls are also manufactured.

Another Boston company, Leslie Co., specializes in baseball headwear and has made caps at one time or another for every big league baseball club. Hatcher Mfg. Co. in Lynn specializes in the manufacture of athletic award jackets for high schools and colleges. Cape Ann Mfg. Co. in Gloucester is a leading producer of boating wear for yachtsmen. Sports Industries Inc. of North Adams is a substantial producer of sleeping bags for campers.

S W Industries, Inc., formerly Stowe-Woodward, Inc., Newton, employing between 300 and 400 people, is an important supplier of bowling balls, while Bowl-Mor Co. in Littleton, a company of appoximately the same size, designs, manufactures and installs automatic pinsetting equipment. Founded in 1949, this company produced the first commercial pinsetter which was installed at the Whalom Park Bowladrome in Fitchburg.

Massachusetts with its 4,230 miles of rivers and numerous lakes and ponds, in addition to 1,980 miles of seashore, is a fisherman's paradise for both fresh and salt water anglers. Supplying their needs in part are three manufacturers of fishing tackle, the N. Y. Toy Game Mfg. Co. of Lawrence, H. J. Collis Mfg. Co. in Taunton, and Sewell N. Dunton & Son, Inc. in Greenfield. Fishing lines are manufactured in Westfield by the U. S. Line Co.

Magnan Manufacturing Company in North Attleboro is the second oldest manufacturer of tennis rackets in this country, having been founded in 1904. They are also one of the two manufacturers of squash and badminton rackets. Another well-known and old established manufacturer is H. Harwood & Sons in Natick, whose specialty is baseballs and softballs.

Massachusetts can claim the distinction of being the home of one of the country's largest manufacturers of ice skates, the Brookfield Athletic Shoe Company, located in East Brookfield. In 1964, this company produced nearly 700,000 pairs of shoe skates in addition to 125,000 pairs of baseball shoes. Two other important producers of ice skate outfits are American Athletic Shoe

Co. in adjacent Brookfield and the Brunswick Sports Products Company in Ware.

MUSICAL INSTRUMENTS AND CAMERAS

About twelve companies in Massachusetts are engaged in the manufacture of musical instruments. Largest is the Aeolian-Skinner Organ Company with plants in South Boston and Dorchester. It is a leader in the field of custom designed pipe organs. All of the instruments built by Aeolian are produced on a contractual basis and are designed for specific installations. Established in 1903 by Ernest M. Skinner, an inventive genius who pioneered many new techniques and tonal improvements in the art of organ building, Aeolian-Skinner has a world-wide reputation for the remarkable tonal quality of its instruments. His successor, a British organ builder, Donald Harrison, contributed still further refinements and improvements in tonal qualities through a series of steps which brought Aeolian-Skinner organs back to the classical concept which prevailed at the time of Bach. A still later improvement was the development of an outstandingly successful device to provide electronically produced reverberations for organs installed in churches lacking good acoustics. Aeolian-Skinner organs are in use in cities all over the United States including Hawaii. They are played in such well-known places as New York's Lincoln Center, Symphony Hall in Boston, The First Church of Christ Scientist in Boston, St. Paul's Cathedral Church, Harvard University Memorial Chapel, the New England Conservatory of Music, and in historic Trinity Church in Copley Square in Boston. An Aeolian-Skinner organ with five manuals and 189 ranks is a part of the famous Mormon Tabernacle in Salt Lake City, Utah. It is also interesting to note that Aeolian-Skinner is the only organ builder that has been commissioned to build instruments for the major symphony orchestras.

Although Massachusetts is no longer the important piano manufacturing center it was forty or more years ago, it has one firm, Tuners Supply Company, now eighty years old that still manufactures piano parts and tools used by piano tuners all over the world.

Massachusetts can lay claim also to being the home of the world's leading maker of cymbals, the Avedis Zildjian Company in North Quincy, which can trace its beginnings back as far as the year 1623. The business was started by a Turkish cymbal-maker by the name of Avedis Zildjian in Constantinople, now called Istanbul. Incidentally the name "Zildjian" in Turkish means cymbal-maker. The closely guarded secrets of the art of cymbal-making have been handed down through many generations of Zildjians. The metal used in making cymbals is an alloy of copper, tin and silver, but the exact formula and how the alloy is prepared is known only to the Zildjians who do all the fabricating and heat treating which results in a finished product with just the right tonal quality.

Boston is known as the "flute capital of the world" because it produces the finest flutes to be found anywhere. Flutes made by the Verne Powell Flute Company and the Haynes Flute Company are played by great musicians in leading orchestras in this country and abroad. Most of these instruments are made of silver, but some are made of gold and cost as much as $3,000. The flute makers also produce fine piccolos, which are made from grenadilla wood imported from Africa.

To fill the needs of America's millions of amateur and professional photographers, Massachusetts industry is well in the forefront of suppliers. It has two sizable companies. The first and largest is Polaroid Corporation in Cambridge which occupies several buildings housing engineering and research activities and facilities for the manufacture of camera products. In addition Polaroid has a complex of newer buildings on Route 128 in Waltham specifically designed for the exacting requirements of making photographic film. Polaroid employs 4,000 people.

Established in 1937 by a brilliant young scientist, Edwin H. Land, then a Harvard undergraduate, Polaroid has grown to be the second largest manufacturer of cameras and photographic products in the United States, exceeded in size only by Eastman Kodak of Rochester, New York. The company was founded as a direct result of Land's invention of the world's first commercial sheet polarizing film, a type of light filter first used by Polaroid to manufacture a new type of sunglass that eliminates reflected glare. By way of explanation, natural light as from the sun is composed of an infinite number of transverse light waves, vibrating in all directions (an up-and-down motion much like water waves). When light waves are restricted to one specific direction of vibration, the light is said to be plane or linearly polarized. When sunlight strikes a smooth surface such as water, sand, road, etc., there is superimposed on the useful reflected light an annoying, information veiling glare component which is highly polarized. Polaroid's polarizing sunglass lenses by virtue of their unique construction selectively screen out

the polarized reflected glare component allowing only useful, informative light to pass through. Its principal products today are Polaroid Land cameras, Polaroid sunglasses, light polarizing filters and optical instruments.

The Polaroid Land camera, which first went on sale late in 1948, met with immediate success. By the end of 1964, over 4 million had been sold. In a succession of improvements and innovations in operating techniques, including faster shutters, the shortening of time required to make a finished print and electric eye exposure control, Polaroid sales soared to new highs each succeeding year. Polaroid introduced its color film early in 1963 and has further improved it since.

The first pictures of the moon's surface, viewed by scientists at the Jet Propulsion Laboratory in California, and taken as U.S. Ranger 7 neared the moon, were ten-second prints made on Polaroid Land film. In 1964, Polaroid infrared film was introduced for applications in laser research, military surveillance, and document analysis.

Polaroid products are sold not only all over the United States but in more than 70 foreign countries. With annual sales of more than $138 million Polaroid ranks 379th in the list of America's 500 largest industrials.

Keystone Camera Company is another company with a success story. Founded in 1919 in the loft of a downtown Boston factory where it rented 3,000 square feet of floor space, it now occupies a five-story plant in Dorchester covering 17 acres. From an original capital of $10,000, its assets have grown to more than $7 million. A pioneer in the field of home movies, it now employs between 600 and 800 people, depending on the season of year. Keystone is the leading New England manufacturer of 8 millimeter home movie cameras and ranks with the top three manufacturers of this style of camera throughout the world. Its products are sold not only all over the United States, but world-wide. New products have been added to its line of home movie cameras and viewing screens and include sound projectors and visual educational aid for schools and industries.

THE LUMBER AND WOOD PRODUCTS INDUSTRY

Production of lumber and wood products, one of the earliest Massachusetts industries, still flourishes in the state. Although wood has been displaced for some purposes by other materials such as plastics and aluminum, the growing utilization of plywoods and the development of other wood materials have been offsetting factors. Important to the wood industry, too, has been the prolonged boom in home building, which has sustained a heavy demand for lumber.

Besides the thousands employed in the paper and furniture industries described in earlier chapters, there are more than 5,000 Bay Staters who get their living from other wood-based industries. These include sawmills and planing mills, millwork plants, box and crate manufacturers, and makers of a variety of wooden products ranging from picture frames to kitchen cabinets.

About two-thirds of the total area of Massachusetts is covered with woodland. The annual forest harvest amounts to about 25,000 cords of pulpwood and well over 100 million board feet of lumber (a board foot is a piece 1 foot wide, 1 inch thick, and 1 foot long). This sounds like a lot of wood, but it represents only about 8 per cent of the amount required each year by the state's wood-consuming industries. Most of the wood has to be imported, and much of it is from the West Coast.

In every section of the state are sawmills and planing mills turning out rough and finished lumber. Other mills specialize in hardwood flooring and wood turnings. Millwork plants produce interior and exterior trim, doors, windows, and cabinets.

One Massachusetts manufacturer employs about 100 persons in the specialized production of louvered shutters and doors. Edward H. Gunter, who owns the Arthur F. Tyler Company in Athol and the Mohawk Millwork firm in Orange, ships his louvered products as far west as the Mississippi River. Louvered doors are being increasingly used in interiors of air-conditioned homes to permit free flow of air from room to room.

One of the largest millwork plants in the state is operated by L. Grossman Sons Inc. in Braintree. There, some 200 workers assemble doors and windows, fabricate trusses, panels and other building components, and make fencing.

The careful attention of craftsmen is required in the manufacture of an organ with exact tonal qualities.

Wes-Pine Millwork Inc. in Hanover manufactures assembled wood windows, exterior door frames, and decorative door entrances. This Hanover firm, employing about 100 persons, produces about 7,500 double-hung windows a month. Brockway-Smith-Haigh-Lovell Company of Charlestown, a leading supplier of doors, sash, millwork, and mouldings to retail lumber yards, employs about 50 persons in such manufacturing operations as glazing window sashes, and setting up building components.

Several millwork plants specialize in producing wooden fixtures for stores and banks. Doane & Williams Inc. in Holyoke is one of the old-timers in this field, having been in business since 1876. Scott & Duncan Company in Boston specializes in the manufacture of wooden fixtures for laboratories. In all, there are nearly 100 millwork plants in the state.

Making prefabricated wooden buildings are more than a dozen firms in Massachusetts. A leader in this field is Hodgson Houses Inc. of Millis, which started making prefab vacation cottages more than 70 years ago. Today their line of homes includes permanent dwellings in the $10,000 to $60,000 class. Another leading producer is Stanmar Inc. in Sudbury, which specializes in vacation cottages and also makes prefabricated churches. Some of the churches produced by the Sudbury firm have auditoriums seating as many as 200 persons and have as many as a dozen classrooms for the church school. Walpole Woodworkers, Inc., a leading producer of rustic fencing, also manufactures prefabricated garden houses and cottages.

Pre-Bilt Construction Company in Dartmouth and Wood Fabricators Inc. in Billerica also manufacture prefabricated buildings.

The manufacture of shoe lasts is one field where wood is rapidly yielding ground to plastics, but some wooden lasts are still produced. United Shoe Machinery's plant in Lawrence and the Vulcan Last Company in Stoughton, two of the largest manufacturers of lasts, now make predominantly plastic lasts. For shoe trees, however, wood is still the favorite material.

Producing wooden boxes, crates and shooks (a shook is a set of parts for a box: the bottom, the top, the sides, and the ends, all ready for assembly) are more than 30 companies in the state. One of the largest in this field is General Box Company in Winchendon who manufacture wire bound shipping containers, boxes, crates and foam plastic packaging. Many firms also make skids and pallets for the transportation and storage of manufactured goods. Kelly Hardwood Corp. of *Pittsfield* is an important supplier of these products.

Among the dozen manufacturers of caskets and burial cases, the largest is National Casket Company of Cambridge. Other large manufacturers include Boston Burial Case Co., Inc., Somerville, Frank E. Sessions Co., Worcester and Florence Casket Co. of Florence.

The uses for wood are countless. A Boston concern, Gerson Company Inc., produces wooden yardsticks and wooden paint paddles as advertising novelties. New England Wooden Ware Corp., Winchendon, manufactures wooden pails and tubs. H. Sacks & Sons Inc. in Brookline makes wood gunstocks. Other wooden products made in the Bay State include barrels, handles for tools and utensils, shipping wheels for wire and cables, cutting boards, trophy shields, mitre boxes, concrete forms, and life preservers.

THE PETROLEUM PRODUCTS INDUSTRY

Massachusetts' production of petroleum products is largely concentrated in the manufacture of road-surfacing materials and roofing products from asphalt. Asphalt is a valuable by-product of crude oil obtained in the refining process for gasoline and fuel oils.

About 72 per cent of the asphalt used in the state is mixed with aggregates (sand and crushed stone) to make bituminous concrete for paving streets, highways, airports, parking lots, and driveways. Nearly 20 per cent goes into the production of roofing materials, and the rest is used in the manufacture of paper laminates, automobile undercoating, paint, cable insulation, and floor coverings.

Warren Bros. Company, internationally famous in paving and highway construction, with 100 plants in the United States and Canada, has its home office in Massachusetts. The firm's headquarters are in Cambridge and it operates six asphalt paving plants in the state. Two plants are in Acushnet, where the company has a quarry, and the others are in Cambridge, Saugus, Swampscott, and Brockton.

Bayer & Mingolla Construction Company in Millbury, one of the largest producers of bituminous concrete in Massachusetts, has six plants in the state, with two each in Millbury, Ashland, and Springfield. It operates its own quarry in Ashland.

Another large bituminous concrete producer is B. A. Simone Inc. in Wrentham, and there are a score of other Bay State companies in the field.

Massachusetts has three large establishments producing shingles and rolled roofing from asphalt.

These are the plants of Bird & Son inc. in Walpole, the Ruberoid Company in Millis, and Lloyd A. Frye Roofing Company in Waltham. Asphalt roofing shingles, commonly used as weather protection for homes, are made by impregnating roofing felt with asphalt. Asphalt is also used as a principal ingredient of roofing preparations applied to flat roofs of large buildings such as schools and factories.

The Waltham plant of the Trumbull Asphalt Company of Delaware makes asphalt roofing preparations. The Webtex Company in Wilmington, primarily a manufacturer of adhesives, also makes roofing coatings and cements. James Huggins & Sons in Malden, founded more than a hundred years ago to manufacture bituminous pipe, produces asphalt emulsions, road tars for highway construction work, coal tar disinfectants and creosote oils.

Leading suppliers of asphalt to the Massachusetts market are Humble Oil & Refining Company, Shell Oil Company, Mobil Oil Company, and Cities Service Oil Company.

Apart from the blending of asphalt products and other specialties there is no petroleum production or manufacturing in Massachusetts, but all of the big oil companies sell gasoline, heating oils, or other petroleum products in the state. Besides Humble, Shell, Mobil and Cities Service, companies which have major distribution facilities in the state include American Oil Company, Atlantic Refining Company, Chevron Oil Company, Gulf Oil Corporation, Sun Oil Company, Tidewater Oil Company, and Texaco, Inc.

Many of these companies have deep water terminals in the Chelsea-Everett-Revere area where they receive oil by tanker from Gulf ports. Mobil has terminals in East Boston and Quincy, Humble has a substantial terminal in Everett, while Cities Service has a terminal in Braintree. Shell's coastal terminal is at Fall River. Several of the companies use pipelines to transport oil to inland distribution points. Shell has a line running from Fall River to Waltham and West Boylston. Humble has one running from Everett to Waltham and Dracut. Mobil supplies a terminal in Springfield by pipeline from Providence, Rhode Island.

Largest of several independent oil companies in the state is the Jenney Manufacturing Company, with headquarters in Newton. This company claims the distinction of being the oldest oil company in America. Founded in 1812, long before the birth of the petroleum industry, the Jenney firm first sold whale oil, then commonly used as a lighting fuel. The company, which has an ocean terminal in Chelsea and operates its own tankers, now sells gasoline and other petroleum products through a chain of 650 filling stations in New England.

Since discontinuance of the Humble refinery in Everett there has been no major refinery in the state. There is, however, a small refinery in Braintree operated by the John L. Ray Company, which specializes in reclaiming used automotive, aviation, and industrial oils. After reprocessing in the refinery these oils are restored to their original purity and may be used

A sheet of roofing felt, saturated with asphalt, coated with soapstone on the back and with layers of granules on the front is cooled as it passes over a series of rolls prior to being cut into shingle strips.

again for the purposes for which they were originally intended.

The White & Bagley Co., Worcester, established in 1888, manufactures automotive oils and greases, and lubricants and coolants for the metalworking industry.

In Norwood, Bardahl Lubricants, Inc. is one of three U.S. licensed blenders of a motor oil additive, Bardahl.

Another firm, Peirce Brothers Oil Service Inc. in Waltham, has an oil-cleaning process by which used crankcase oil can be converted into heating oil.

The manufacturing operations of the big oil companies in the state are largely limited to the blending of oils to produce special-purpose industrial oils. One company, Mobil, does have a small operation at its East Boston terminal packaging oil in quart cans, drums, and barrels.

A few manufacturing companies in the state, in a technical sense, do not fall within the scope of the major industries described in this book. Yet they all contribute their important share to the state's economy.

Some of these companies are unique in that they may be the only manufacturer of their particular product within the state. Others may be part of a very small, specialized segment of an industry either within the state or even within the nation. For instance, there are several companies producing various kinds of brushes. Whiting-Adams Co. Inc. Division, Star Brush Manufacturing Company, Colonial Brush Mfg. Co., Inc., Baltimore Brushes, Inc., and American Brush Company, all of Boston, manufacture paint brushes. In Westfield, Kellogg Brush Manufacturing Co. produces household brushes, while in Palmer, Better Brushes Division of Sanderson-MacLeod, Inc. manufactures both household and twisted-in-wire brushes. Other firms specialize in wire brushes or in household mops and other specialty brushes for both home and industrial use. In Hyannis, Colonial Candle Company is a large producer of hand-dipped and other specialty type candles. In Revere, Hy-Sil Mfg. Co. manufactures Christmas ribbons, gift wrapping papers, and metallized plastic film, while in Boston, Bradford Novelty Company specializes in Christmas ornaments.

In Groton, the Groton Leatherboard Company produces matrix or dry mats for stereotypers and newspapers. In Cambridge, the Webster Unit of the Copying Products Division of Interchemical Corporation produces carbon papers, inked ribbons, and related duplicating supplies. This company, Ace Carbon Company, Boston, and Technicarbon, Inc., Holyoke, produce one-time carbon paper. P. F. Avery Corporation of Billerica designs, develops, engineers, and manufactures nuclear hardware, pressure vessels, and components. Bunny Bear, Inc. of Everett specializes in nursery room accessories such as mattresses and padded goods for infants and children. These are but a few examples of unusual corporate enterprises.

AND OTHER INDUSTRIES

The list of "Made in Massachusetts" products is indeed a diverse one, ranging the alphabet from atomizers and artificial eyelashes to Za-Rex fruit punch. From Massachusetts factories come lamps and lampshades, advertising and display signs, hearing aids, morticians' goods, artists' supplies, doughnut, muffin and cake mixes, liquid starch, peanut butter and salted peanuts, mixed nuts, fruit juices, needles and pins, spring water and soda pop, manufactured ice in cakes and cubes, grease and tallow, uniforms, sawdust and excelsior, rubber stamps and marking devices. The number of products is virtually endless.

All the industries constituting the industrial complex of Massachusetts cannot be included in a single volume, nor can the complete story of Bay State industry ever be really concluded. Industry in Massachusetts, as it is throughout the United States, is dynamic and constantly changing. Products, companies, and people change in line with the competitive demands of economic life. While such competition is common to all American industry, its challenge is greater for our older and more mature economy, for we not only lack natural resources to produce our products but we are also located in the northeast corner of the United States with our major markets constantly moving westward with the population shift.

Thus the challenge to the publishers of this book has been to highlight the vast array of industrial activities within the Commonwealth so that the reader may gain better insight and understanding of the vital force that makes our economy tick, that provides more employment than any other job category in the Commonwealth: the manufacturing industries of Massachusetts.

Massachusetts Industry
Progress Through enterprise

PHOTO CRE

Primary Metals Industry
U.S. Steel—Worcester Works; N
poration; Wyman-Gordon Comp
Works; Metals and Controls Inc.
struments, Inc.

Fabricated Metals Industry
Simonds Saw and Steel Company
Company; United-Carr Inc.; Lars
Company; Worcester Pressed St
Harrington Cutlery Company

Machinery Industry
Draper Corporation; Morgan C
Rice Barton Corporation; Gilbert
turing Company; Whitin Mach
Machinery Company

Stone, Clay and Glass Industry
Bay State Abrasive Company; N
Aero Systems Company; Charles
Eastern Schokcrete Corporation

Ordnance Industry
General Electric Company; Sylva
Inc.; Raytheon Company

Electronics Industry
Sylvania Electric Products, Inc.;
National Research Corporation;
Data Processing; High Voltage Er

Instruments Industry
The Foxboro Company; Radio Corporation of America; Instron Engineering Corporation; Raytheon Company; David W. Mann Company—Division of FCA Corporation

Space Industry
NASA; General Electric Co.; Raytheon Company; Honeywell, Inc.; National Research Corporation

Paper Industry
Byron Weston Company; U.S. Envelope Company; Ludlow Corporation; Technifax Corporation

Printing and Publishing Industry
Rust Craft; The Plimpton Press

Transportation Industry
General Dynamics Corporation—Electric Boat Division; O'Day Corporation; Maxim Motor Company; American Bosch Division—American Arma Corp.; The Columbia Manufacturing Co., Inc.; General Motors

ston Gas Company;
New England Tele-
onquin Gas Trans-

Breck Company;
naceutical Products,

n—W. R. Grace &
Company; American
Company

Kendall Company;
ern Textile Associa-

Cape Ann Manufac-

ion; Compo Shoe

efield Company

s Association; Mass. Department of Commerce; Ocean Spray Cranberries, Inc.; Domino Sugar; Howard Johnson's Company; Clark-Babbitt Foods, Inc.

Jewelry and Silverware
L. G. Balfour Company; Reed and Barton; Towle Silversmiths; Swank, Inc.

Research and Development Industry
Raytheon Company; Fabric Research Laboratories, Inc.; National Research Corporation; General Electric Company; Avco Research and Advanced Development

Other Industries
Vogue Dolls, Inc.; Milton Bradley Company; A. G. Spalding and Bros., Inc.; Aeolian Skinner Organ Co., Inc.; Bird and Son, Inc.